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EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

Public Health Service
New York, New York

1960

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EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF
NARRAGANSETT BAY

1960

Prepared for
U. S. Army, Corps of Engineers
New England Division

by
U. S. Department of Health, Education, and Welfare
Public Health Service
Regions I & II
New York, New York

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SUMMARY

a. Background As part of an analysis of proposed hurricane protection devices in Narragansett Bay, the U. S. Army, Corps of Engineers, New England Division requested the Public Health Service to conduct a study to determine the effects of these Lower Bay barriers on water quality. A field survey conducted during June to August of 1959, which concentrated in Upper Narragansett and Mount Hope Bays as well as in the Providence and Seekonk Rivers, provided the major portion of the basic data from which the effects of the barriers were estimated. Samples in Upper Narragansett and Mount Hope Bays were collected daily, except weekends, at 19 stations at five feet below the water surface and five feet from the bay bottom. A total of some 1400 samples were collected on which analyses were made for specific conductance, temperature, dissolved oxygen and most probable number of coliform organisms (MPN). At selected stations and times, analyses were also made for biochemical oxygen demand. An additional 10 stations in the Providence and Seekonk Rivers were occupied twice each day, except weekends, with samples collected at three feet from the water surface and three feet from the river bottom. This resulted in a total of about 1500 samples which, except for MPN, were analyzed for the same variables mentioned previously.

b. Conditions during 1959 survey Weather conditions during the survey were somewhat abnormal with periods of relatively heavy precipitation and accompanying heavy cloud cover followed by periods of clear skies. The prevailing winds were from the south south west with average velocities of 5-10 mph and gusts up to 30 mph. The amount of fresh water entering the Bay during the survey varied from a maximum flow of about 4500 cfs to a minimum flow of about 650 cfs.

c. Results of survey The degree of average vertical stratification in chloride concentration (as measured by specific conductance) is greatest in the Providence and Seekonk Rivers and Mount Hope Bay. The largest degree of vertical stratification occurred in the Seekonk River where a difference of about 6.8 parts per thousand (o/oo) was observed. The average chloride conditions indicate a general tendency for the surface waters to flow in an outward direction.

d. An examination of the average temperature conditions indicates that vertical stratification is almost uniform averaging about 2-2.5°C.

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throughout the study area. There appears to be a general flooding from the West Passage into the Upper Bay as well as the possibility of relatively strong upwelling off Warwick Neck due to predominantly divergent currents.

e. For dissolved oxygen the degree of vertical stratification increases in the Providence and Seekonk Rivers with a maximum average stratification of 4.0 ppm occurring in the upper end of the Seekonk River. Lowest dissolved oxygen concentrations occurred in the bottom waters.

f. Average MPN/100 ml conditions during the survey indicate a marked degree of vertical stratification with the greatest stratification occurring in the lower end of the Providence River. At this location geometric mean surface MPN was about 2260/100 ml and geometric mean bottom was about 210/100 ml.

g. In general, the variation in surface quality at any given station during the survey was quite large. For example, in the Providence River surface dissolved oxygen varied from 1.4 ppm to 11.2 ppm. Bottom variation was relatively small during the survey. Three general periods of increased mixing of surface into bottom waters were noted.

h. Analysis and interpretation of data A three cycle sinusoidal analysis was the primary method of describing the changes in water quality. The three cycles chosen were an annual one of 365 days, a lunar month of 29.54 days (from new moon to new moon) and a tidal cycle of 12.42 hours (from high water to high water). The data collected at a given station were fitted to a general equation by the method of least squares. The results of the analysis of the chloride data indicated that surface chloride concentrations are affected primarily by the time of year, thereby implying the effects of almost periodically recurring meteorological conditions, most probably the fresh water inflow pattern. Tidal variations in surface chloride concentrations are present with an average amplitude of about 0.6 o/oo. Bottom chloride variations are affected primarily by tidal influences and not to any great extent by seasonal factors. Average amplitude over a tidal cycle is also about 0.6 o/oo. There appears to be a general net seaward flow on the surface and a net landward flow along the bottom, although this is not true for all locations.

i. Both surface and bottom water temperatures in the area studied are affected primarily by the time of year implying the pronounced effects of seasonal changes in air temperatures. Small tidal cycle temperature variations are present ranging from about 0.5-1.5°C. The analysis of the temperature data further confirmed the general presence of a two-layered system. A complex situation consisting of vertical, lateral and longitudinal current gradients exists in the upper end of East Passage, which may be due to the flooding from West Passage and the Warren River into the Upper Bay. This flow deflects the flooding East Passage channel water back on itself imparting a semi-rotational motion in the Upper Bay.

j. Analysis of the dissolved oxygen data indicates that at most stations "high" and "low" values of surface dissolved oxygen may occur at various times during the year. This appears to reflect the influence of aperiodic short term meteorological influences as well as the relatively unpredictable results of photosynthetic action by aquatic plants. Tidal cycle variations are present and of the three cycles used in the analysis, these are relatively predominant. Average amplitude during a tidal cycle is about 1.0 ppm. The dissolved oxygen of the bottom waters is markedly influenced by the time of year probably indicating the influence of seasonal variations in water temperatures. Apparently, the bottom layers are not subjected to the same factors which affect the surface layers. Some relatively crude estimates of the power spectrum at one station during the survey indicated that a rainfall cycle of about 28 days, which occurred during the survey, may possibly be a contributing factor to the total variation in surface dissolved oxygen. At some stations the dissolved oxygen pattern appeared to follow a two-layered system although this was not as marked as for the chloride variation.

k. In general, the seasonal effect on both surface and bottom MPN is not predominant and "high" and "low" values at a station may be expected to occur at almost any time of the year. The tidal cycle influence appears to be the greatest of the three cycles used, although other causes, which were not tested, contribute significantly to the total variation. A rough indication of the causes of variation in MPN based on some crude estimates of the power spectrum during the survey indicates that rainfall (and its indirect results) may possibly be a contributor to the total MPN variation. Highest MPN counts in the study area occurred between HW 3.1 and HW 6.2 hours. Flooding from West Passage and the Warren River results in a channelling effect of high MPN waters into the upper end of East Passage.

l. Effects of hurricane barriers under Plan 35 on water quality The analysis of the effects of the barriers under Plan 35 was made for dissolved oxygen and MPN. For the former, the barriers will, in general, have little effect on the dissolved oxygen resources of the area. Average dissolved oxygen during a tidal cycle will decrease slightly and at some stations the barriers will have no effect. During the various phases of the tide, the barriers will tend to lower the maximum dissolved oxygen levels while raising the minimum dissolved oxygen levels, but usually not by the same amount. Hence, the degree of vertical stratification will increase. Increased vertical stratification in the case of dissolved oxygen could be beneficial, since the surface dissolved oxygen will no longer drop to as low a level after the barriers as before the barriers. Since the major effect in vertical stratification consists of a decrease in the surface dissolved ocygen variations, low dissolved oxygen values at certain stages of the tide will be prevented although the mean dissolved oxygen will decrease. It is not believed that the effects of these changes will be pronounced. Indeed, it is doubtful if the changes could be measured after the barriers are constructed, i. e. the changes appear to be of an order of magnitude such that the effects of other factors may mask their determination.

m. The net change in MPN during a tidal cycle after the barriers are in place is expected to be small and within the limits of the accuracy of the MPN test may be considered to be negligible. In general, at those stations where the MPN is measurably affected by the tide, the effects of the barriers will be to increase the MPN at high water and decrease the MPN at low water. Essentially, this results in decreased vertical mixing during the different stages of the tide. From an area wide point of view, the most cirtical location appears to be the entrance of the Providence River into the Upper Bay where the change in flood current occasioned by the barriers results in insufficient current velocity to "push" Upper Bay water into the Providence River. On the other hand, the reduced ebb current velocity results in a "holding-back" of high MPN waters in the Providence River. As with the dissolved oxygen, it is not believed that changes estimated to occur in the MPN will result in pronounced effects. Since the greatest portion of the total MPN variation is due to causes which are not assumed to be affected by the barriers, the determination of these small changes after the barriers are constructed would be extremely difficult.

EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

SECTION I - FOREWORD

Scope

1. History The extensive damage to property and human life resulting from a long history of severe hurricanes in the Narragansett Bay area resulted in a study by the U. S. Army, Corps of Engineers, New England Division under authority contained in Public Law 71, 84th Congress to determine feasible methods of protection. The Corps of Engineers subsequently investigated many different types and locations of hurricane barriers to prevent widespread storm flooding. These preliminary studies resulted in a recommendation to study further a system of protection devices known as the Lower Bay Barriers and the Fox Point Barrier in the Providence River. Since these barriers, depending on the size of the navigational opening, will restrict tidal movement into the Bay area, concern was expressed that water quality conditions might be impaired. The Corps of Engineers then requested the Public Health Service to prepare a preliminary report on the effects of the Lower Bay Barriers with specific navigational openings. This report1/ was transmitted to the Corps of Engineers in February, 1957 and a summary of the conclusions was included in the Letter from the Secretary of the Army. 2/ The report concluded qualitatively that the indicated openings in the barriers "...will cause increases in pollution concentrations in the vicinity of pollution sources, and will also tend to concentrate pollution in the surface water layers..." The report further concluded that additional data were needed to determine quantitatively the effects of the barriers.

2. The Corps of Engineers under a letter dated April 10, 1959 then requested the Public Health Service to undertake a more extensive study including field surveys to determine the effects of the barriers on water quality. The following report includes the results of the field survey together with the estimated effects of the contemplated barriers on the quality of Narragansett Bay.

1/ This and the following footnotes refer to respectively numbered entries in the Bibliography at the end of the report proper.

3. Purpose The purpose of this report is to determine whether the proposed Lower Bay barriers will have any measurable effect on the quality of the waters of Narragansett Bay. These effects, whether beneficial or detrimental, will then be included by the Corps of Engineers in their assessment of the overall effects of the barriers on the many water resource aspects of Narragansett Bay.

4. Organization The report proper includes a general discussion of the features of the Bay which have a bearing on an evaluation of water quality. The results of the field survey in 1959 are discussed and the basic data are presented in Appendix A. Analysis and interpretation of the data are included and the more technical details regarding this phase of the report are presented in Appendix B. The results of the various analyses performed on the data are then described. Finally, the effects of the barriers on the present quality of water are discussed.

5. Acknowledgements A report of this type requires the cooperation of many organizations and individuals for its successful completion. The cooperation and expressed efforts of the following are appreciated.

Federal Agencies
  Department of Defense
    U. S. Army, Corps of Engineers, New England District
  Department of Interior
    Geological Survey
    Fish and Wildlife Service
  Department of Commerce
    Weather Bureau
    Coast and Geodetic Survey

State Agencies
  Rhode Island
    Department of Health
    Department of Public Works, Division of Harbors and Rivers
    Department of Agriculture and Conservation,
      Division of Fish and Game
  Massachusetts
    Department of Health

Municipal Agencies
  Blackstone Valley Sewerage Commission
  City of Providence, Rhode Island

Universities
  University of Rhode Island
    Department of Civil Engineering
    Narragnasett Marine Laboratory

Others
  Edgewood Yacht Club

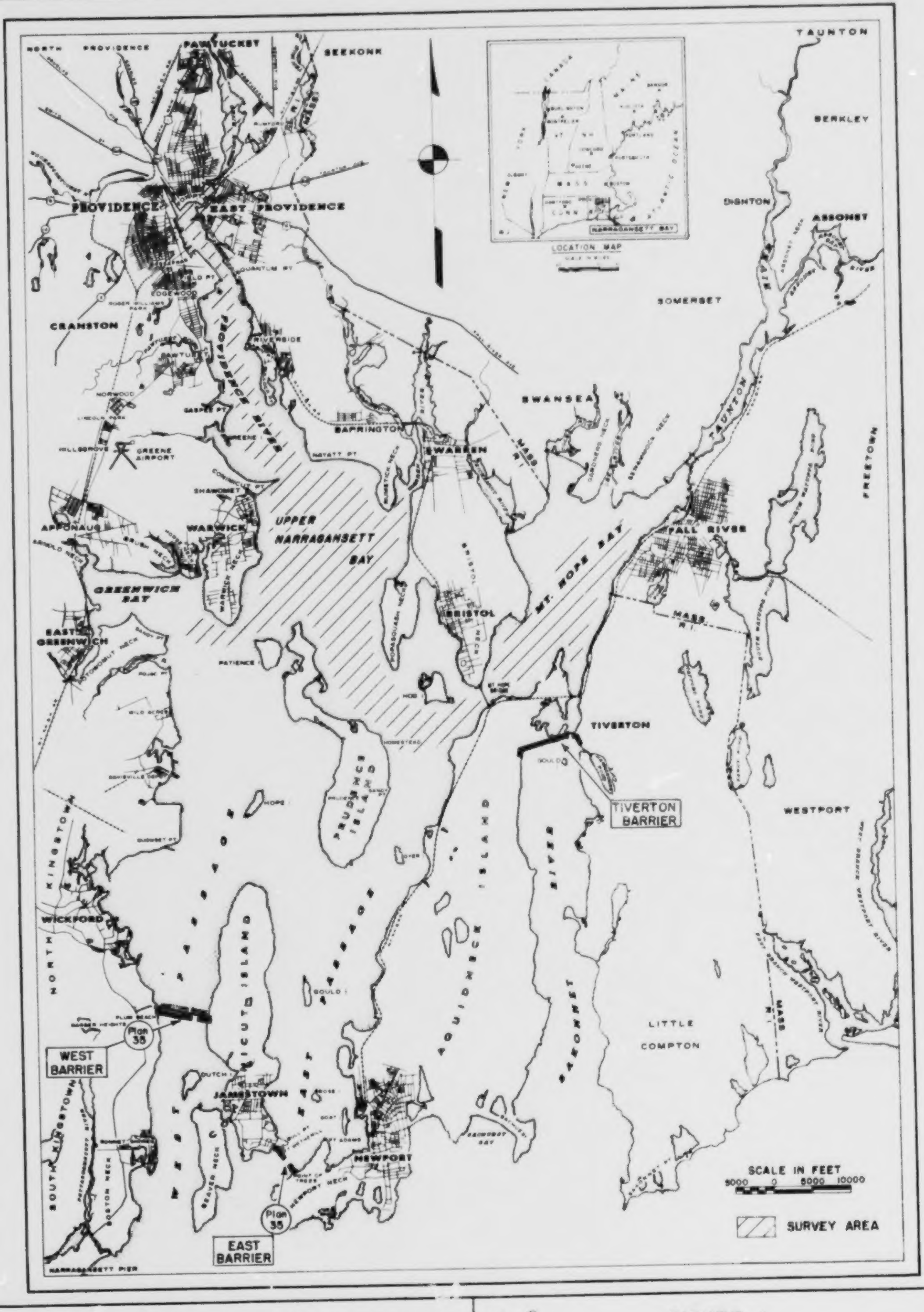
SECTION II - INTRODUCTION

General

6. Area covered This report deals primarily with the Upper Narragansett Bay area including Mount Hope Bay and all the major estuaries to the upper point of influence by the tides. Preliminary consultations indicated that water quality problems were most pronounced in this area. Also, previous sampling of the lower portion of the Bay indicated that in general these waters were of good quality. Since the major effects of the barriers on water quality will be in those areas presently subjected to large variations in the quality of water, this definition of the area to be covered is considered to be logical. Occasional reference is made to the entire area which drains into Narragansett Bay. Reference is also made to the quality of water entering the tidal estuaries. The area covered in this report is depicted in Figure 1.

7. Description of area The water area of Narragansett Bay is about 140 square miles with a total shoreline of approximately 250 miles including islands in the Bay. In general, the economy of the area is a highly industrialized one consisting mainly of textile, metal manufacturing and jewelry industries. The centers of these industrial complexes are located principally in Providence, R. I. and Fall River, Massachusetts. Climatologically, the Bay area is subject to the "prevailing westerlies" with wind and storms traveling primarily from the south and southwest. Average annual air temperature is about 8°C. varying to about 22°C. during the summer months and about -1°C. during winter months. Average annual precipitation over the area is about 45 inches with short periods of relatively intense rainfall during the summer months. More complete general descriptions are given in other reports.3/ 4/

8. Water uses The waters of Narragansett Bay play an important role in the economy of the surrounding area. The maintenance of suitable conditions for the propagation of fish and shellfish is necessary to the economy of many people along the shore line. Figure 2 indicates those portions of the study area which are presently closed to the harvesting of shellfish for direct marketing. The closing of these areas has been made by the appropriate State agencies on the basis of sanitary surveys together with sampling of the waters for coliform bacteria. Likewise,


NORTH PROVIDENCE
PAWTUCKET
SEEKONK
TAUNTON
BERKLEY
PROVIDENCE
EAST PROVIDENCE
DIGHTON
ASSONET
SOMERSET
CRANSTON
EDGEWOOD
RIVERSIDE
PROVIDENCE RIVER
BARRINGTON
SWANSEA
WARREN
TAUNTON RIVER
GREENE AIRPORT
APPONAUG
WARWICK
UPPER NARRAGANSETT BAY
MT. HOPE BAY
FALL RIVER
FREETOWN
GREENWICH BAY
EAST GREENWICH
BRISTOL
MASS.
R.I.
PATIENCE I.
PRUDENCE ISLAND
TIVERTON
TIVERTON BARRIER
WESTPORT
NORTH KINGSTOWN
WICKFORD
WEST PASSAGE
EAST PASSAGE
CONANICUT ISLAND
AQUIDNECK ISLAND
SAKONNET RIVER
LITTLE COMPTON
Plan 35
WEST BARRIER
JAMESTOWN
NEWPORT
SOUTH KINGSTOWN
BEAVER NECK
Plan 35
EAST BARRIER
NARRAGANSETT PIER
LOCATION MAP
NARRAGANSETT BAY
SCALE IN FEET
5000 0 5000 10000
SURVEY AREA

EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

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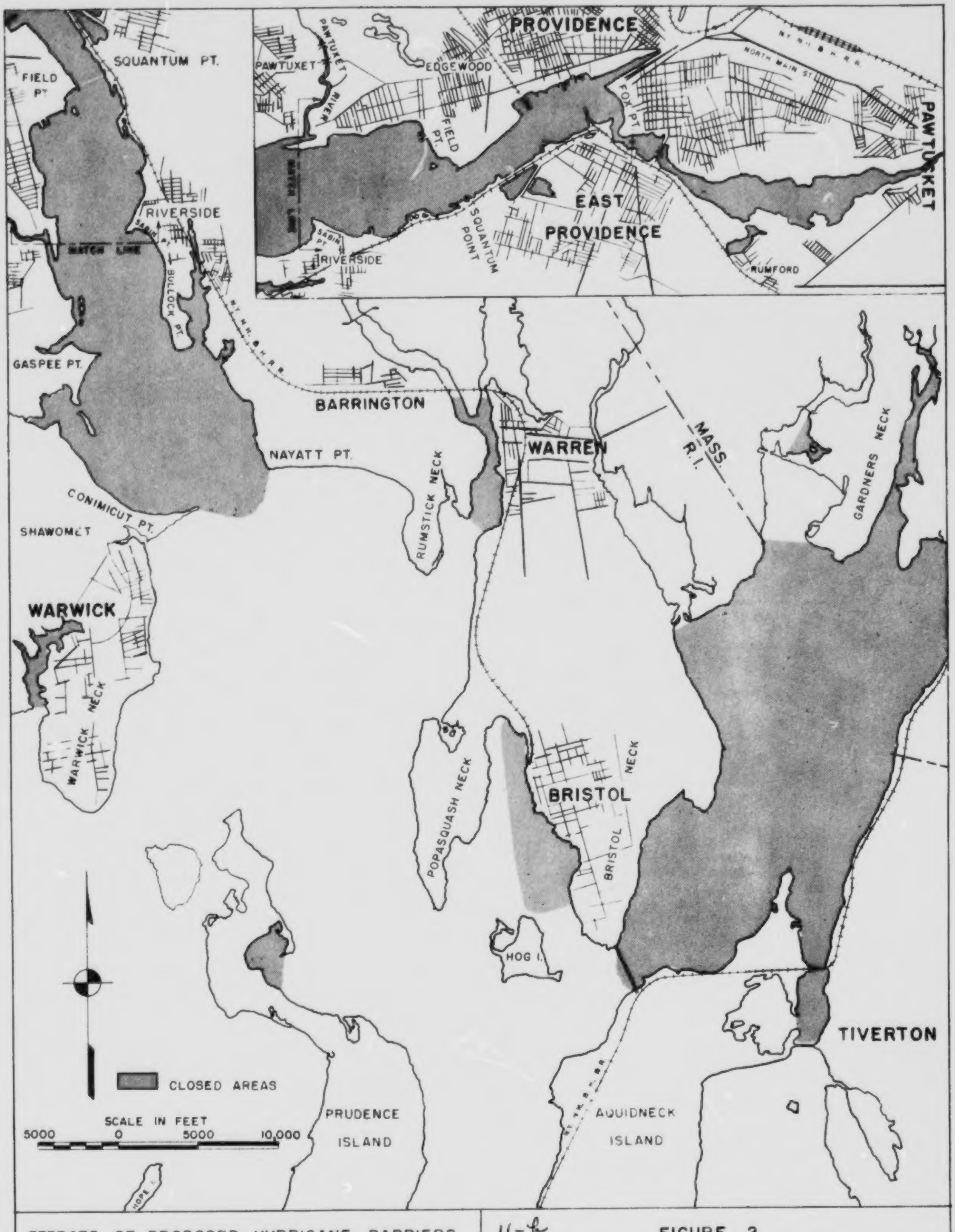
PUBLIC HEALTH SERVICE

4-a

FIGURE 1

NARRAGANSETT BAY


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
PAWTUCKET
EAST PROVIDENCE
SQUANTUM POINT
SABIN PT.
RIVERSIDE
RUMFORD
MATCH LINE
SQUANTUM PT.
FIELD PT.
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
WARWICK
WARWICK NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
CLOSED AREAS
SCALE IN FEET
5000
0
5000
10,000

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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FIGURE 2
AREAS CLOSED TO SHELLFISH
TAKING FOR DIRECT MARKETING

the waters afford recreational opportunities for thousands of metropolitan dwellers and water sports enthusiasts. Direct withdrawals of water for industrial purposes are limited more to the tidal rivers of the Bay and it has been estimated that about 700 million gallons per day (mgd) is withdrawn from salt water areas for cooling purposes in the generation of thermoelectric power. 4/ Finally, the waters of the Bay are used for purposes of waste disposal by the municipalities in the area draining into the Bay. Hence, the waters of Narragansett Bay under study in this report are used for almost all water uses except public water supply.

9. Water movements in the Bay Figure 1 indicates the complexity of the problem of water movements in Narragansett Bay resulting from the many interconnecting passages and varying depths. Probably the most comprehensive analysis of the tidal currents in the Bay was made by Haight in 1938 on data collected primarily during 1930 and 1931. 5/ The Narragansett Marine Laboratory of the University of Rhode Island since 1951 has conducted a series of investigations financed by funds from several Federal agencies to determine water movements throughout the Bay. 6/ 7/ 8/ These investigations included studies of temperature and salinity distributions as well as tidal current patterns. Hicks has summarized and interpreted the results of these and previous studies. 9/ Briefly, the movement of water in the Bay is of the standing wave type where slack currents occur at approximately high and low water. The difference in the time of occurrence of high water throughout the Bay is about ten minutes. The mean tidal range varies from 3.5 feet at Newport to 4.6 feet at Providence. The time between high and low water averages six hours and twelve minutes.

10. Hicks' analysis of the physical data indicated that the estuary may be classified as a two-layered system where the non-tidal motion is seaward in the surface layers and landward along the bottom. The difference between the net outflow and inflow is the amount of fresh water entering the Bay system. This was confirmed to some degree for the Providence River by a series of limited current observations made in 1959 by the Coast and Geodetic Survey for the Corps of Engineers. An analysis of the data collected by the Public Health Service and reported on in this report also indicates that this may be the case. Frequent reference will be made throughout this report to the results and conclusions of the aforementioned studies.

11. Fresh water inflow The main sources of gaged fresh water inflow into Narragansett Bay are the Blackstone River, Taunton River, Pawtuxet River and the Woonasquatucket River. Some of the pertinent details regarding the flows of these rivers are given in Table 1. All of these streams discharge to estuaries in the section of Narragansett Bay under study in this report. These streams are regulated in varying degrees for industrial purposes. Additional discussion on the variations of the fresh water flow of these rivers during the time of the 1959 survey and the effects on water quality is given in Section III - Water Quality of Narragansett Bay.

12. Pollution load Three rivers and five major sewage treatment plants contribute the largest part of the pollution loading in the study area. The Pawtuxet, Blackstone and Woonasquatucket Rivers discharge into the study area. The pollution load carried by these streams into the study area reflects discharges of municipal and industrial wastes in the upper non-tidal reaches of these streams. The Providence and East Providence plants are equipped with secondary treatment while Fall River, Bristol and the Blackstone Valley Sewer District have primary facilities. Table 2 lists the average daily flows of the plants and rivers in 1957 and the pollution load discharged, based on Population Equivalents (P. E.) calculated from the 5-day biochemical oxidation demand.[10/] [11/]

13. Total pollution load discharged into the Providence River amounts to about 700,000 P. E. In addition, storm water overflows from combined sewers discharge directly into the waters of the study area. Values for all three rivers in Table 2 were calculated from unpubliched data prepared by the Rhode Island Department of Health.

14. Proposed Lower Bay Barriers, Plan 35 Hurricane barriers in the lower bay were designed and located (see Figure 1) to minimize the flooding effects of a major storm. Extensive hydraulic model investigations of three of the barriers were carried out at the Waterways Experiment Station at Vicksburg, Mississippi.[12/] The barrier proposed for the Sakonnet River is gated, enabling full closure during a hurricane. Locations of barriers in the East and West Passages indicated the use of openings which will be able to meet the navigational requirements of the various craft using Narragansett Bay while providing reasonable hurricane protection for the area.

TABLE 1

FLOWS OF SIGNIFICANT FRESH WATER STREAMS DISCHARGING TO NARRAGANSETT BAY

(Cubic feet per second)

Fresh Water Stream	Yrs. of Record*	Discharge Average	Discharge Average Min.monthly	Estuary Receiving Fresh water stream
Blackstone River at Woonsocket, R. I.	29	734	182	Seekonk River
Taunton River at State Farm, Mass.	29	455	76	Mt. Hope Bay
Pawtuxet River at Cranston, R. I.	18	338	130	Providence River
Woonasquatucket River at Centerdale, R. I.	17	70	23	Providence River

*Water years through September 1958

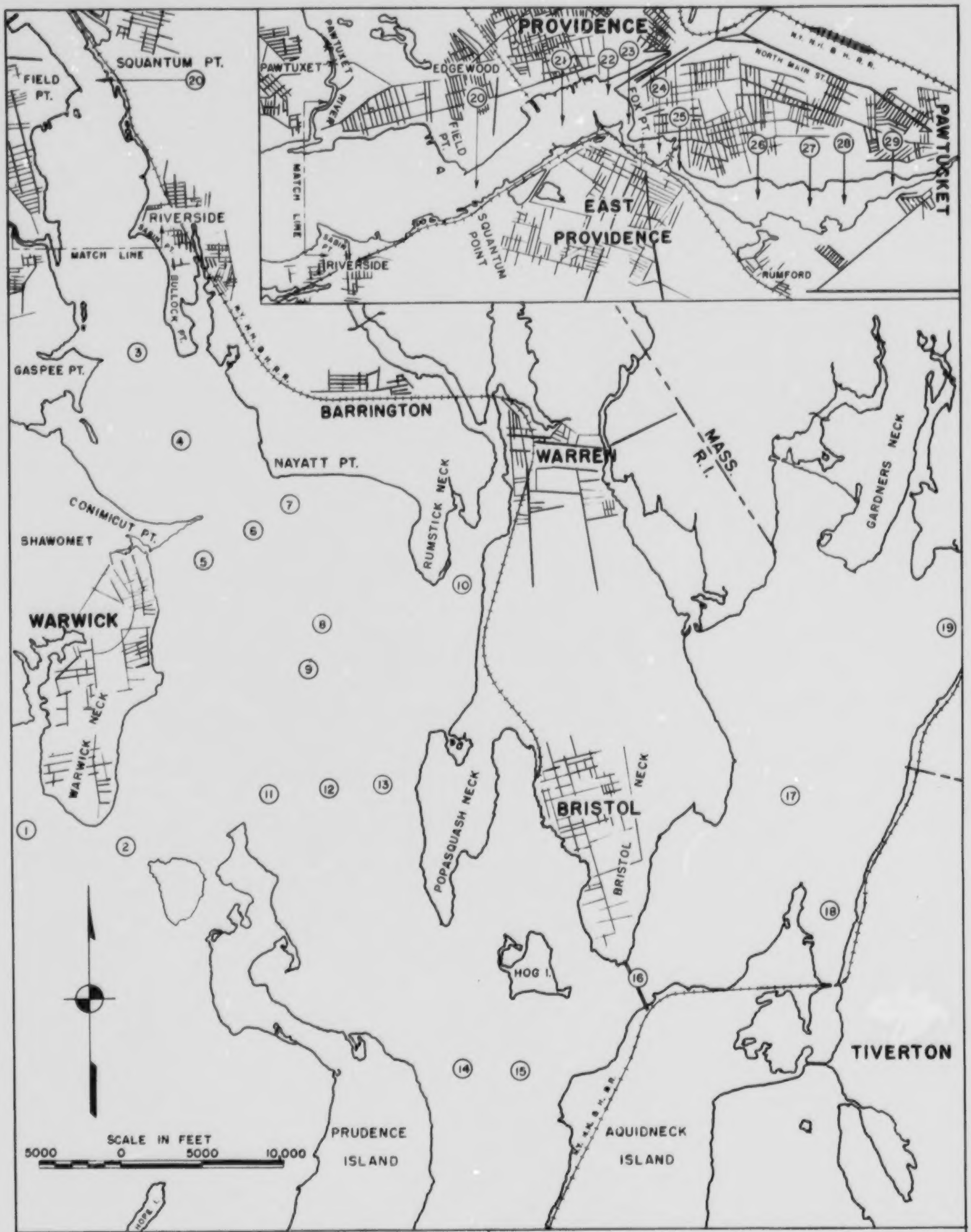
TABLE 2

ESTIMATED POLLUTION LOADS IN STUDY AREA

1959

	Average Flow (mgd)	Pollution Load Discharged (PE)*
Plants		
Providence	45.0	380,000
E. Providence	1.85	3,300
Blackstone Valley S. D.	16.0	160,000
Fall River	11.6	72,000
Bristol	1.97	7,000
Rivers		
Pawtuxet (Above Dam)	200	80,000
Blackstone	279	59,000
Woonasquatucket	34	29,000

* PE - Population equivalent based on 0.17 pounds of biochemical oxygen demand per person per day.


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
NY. NH. & H. R.R.
PAWTUCKET
MATCH LINE
SQUANTUM POINT
EAST PROVIDENCE
RIVERSIDE
SABIN PT.
RUMFORD
SQUANTUM PT.
FIELD PT.
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
SCALE IN FEET
5000
0
5000
10,000
1
2
3
4
5
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EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

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FIGURE 3
LOCATION OF SAMPLING STATIONS
DURING 1959 SURVEY

TABLE 3

EFFECTS OF BARRIERS ON TIDAL HEIGHTS AND CURRENT VELOCITIES AS DETERMINED BY MODEL TESTS

Tidal Heights - Plan 35 (Figure 1 & 3)

	Base Test (Normal Tide)			Plan (Normal Tide)		
Location	High Water	Low Water	Tidal Range	High Water	Low Water	Tidal Range
Station 2	4.2	-0.5	4.7	3.4	0.5	2.9
Warwick	4.2	-0.4	4.6	3.6	0.7	2.9
Field Point*	4.4	-0.6	5.0	3.3	0.3	3.0
Providence-Sta. 21	4.4	-0.7	5.1	3.7	0.7	3.0
Bristol Harbor	4.4	-0.3	4.7	3.3	0.7	2.6
Warren	4.8	0.3	4.5	3.5	0.7	2.8
Nayatt Point	4.2	-0.5	4.7	3.5	0.7	2.8
Bullock Point	4.4	-0.4	4.8	3.4	0.5	2.9
Bristol Ferry	4.2	-0.4	4.6	3.4	0.5	2.9
Station 18	4.3	-0.3	4.6	3.5	0.6	2.9
Station 19	4.3	-0.7	5.0	3.5	0.5	3.0
Station 16*	4.2	-0.4	4.6	3.4	0.5	2.9
Stations 14 & 15	4.3	-0.3	4.6	3.4	0.6	2.8

* Basic test and plan astronomical tide heights for Plan 35 at locations indicated were observed on permanent-type point gages and are accurate to less than 0.1 feet prototype.

Note: Elevations are in prototype feet. Elevation 0.0 is mlw Newport which is 1.6 feet below msl.

Current Velocities - Plan 35 (Figure 3)

	Station 2		Station 13		Station 16		Station 3	
Hour	Base	Plan	Base	Plan	Base	Plan	Base	Plan
0.0	-1.3	-0.7	-0.5	-0.3	-1.5	-0.7	-1.0	-0.5
3.0	1.0	-0.3	0.4	0.0	0.6	-0.4	0.6	-0.2
6.0	1.3	0.9	0.5	0.4	1.5	0.7	0.7	0.2
9.0	-0.6	0.5	-0.3	0.2	-0.5	0.6	-0.5	0.3

Note: Minus signs indicate ebbing velocities. Prototype velocities were determined by timing the travel of a 14-foot pole float. Times are expressed in terms of prototype hours after the moon's transit of meridian 71°21'.

15. Model studies of the effects of the Plan 35 barriers on tidal ranges in the Providence River area revealed a reduction of 40% at Nayatt Point (Figure 3) at the river's mouth and a reduction of 41% at Providence (see Table 3). These reductions are for spring tide conditions. Similar reductions were observed for Mount Hope Bay. Current velocities in areas upstream from the barriers were generally reduced by the same percentages. Table 3 illustrates that the barriers changed some ebb flows to flood and vice versa.

16. Table 3 shows that the reduction in the tidal range is composed of a decrease in the high tide and an increased low tide. The principal portion of the reduction was contributed by the drop in the average height at high water.

SECTION III - WATER QUALITY OF NARRAGANSETT BAY

Introduction

17. This section presents an analysis of the data collected during the summer of 1959 to determine the quality of water and as far as possible the factors which affect this quality. The study area was described in Section II, paragraph 6 and is outlined in Figure 1. The indicators of water quality used in this report are the dissolved oxygen and the Most Probable Number of coliform organisms (MPN). Chloride data are used to determine physical water movements in the area and temperature data are used both for physical movement indications and for its effects on dissolved oxygen and MPN. In addition, limited data were collected to determine the biochemical oxygen demand of the waters of the study area. At some locations in the study area additional information was available from previous surveys which has been incorporated as far as possible into the 1959 data to determine quality levels during times other than the survey period. These previous surveys are discussed below.

18. Previous water quality surveys Much of the past sampling of Narragansett Bay to determine water quality has been in connection with the suitability of the waters for shellfish cultivation. Consequently, the samples taken during these surveys were analyzed primarily for Most Probable Number of coliform organisms. Since the greater part of the study area lies within Rhode Island, this State has done the majority of previous sampling. These surveys were dictated primarily by suspected changes in pollution load which would possibly result in changes in the shellfish classification of the overlying waters. Further, the resources of the Health Department, which conducted the bulk of the sampling, were limited and careful planning was needed in order to sample all of the areas at the necessary times. If no changes in pollution loading for a particular area were suspected, the results of the initial survey were assumed to apply.

19. The quality surveys indicated above were supplemented from time to time by Health Department surveys to obtain information on the dissolved oxygen and biochemical oxygen demand concentrations. These surveys were concentrated mainly in the Providence and Seekonk River areas.

20. As part of a survey to determine the effects of the proposed hurricane barriers on the physical oceanography of the Bay and subsequently on the fishery resources, the Narragansett Marine Laboratory made a series of surveys which included the analyses of samples for dissolved oxygen, temperature and salinity.[7] [8] [13] These surveys were concentrated mainly during the years 1955-1957. For the latter year, samples were obtained once during each of the four seasons of the year at stations throughout the entire Bay which afford an opportunity to estimate year-round quality variations.

21. It is seen then, that the samples which have been collected in the past were obtained at odd intervals and were analyzed in most cases for different quality characteristics. It is extremely difficult, therefore, to arrive at an accurate determination of the water quality of the study area and the factors which may affect the quality from these previous results. The aspect most lacking in all of the above surveys was that of a sufficient length of time in the sampling at each station. In order to arrive at a more meaningful picture of the variations in water quality in the study area, a comprehensive survey was undertaken during the summer of 1959.

1959 Survey

22. *Location of stations* Figure 3 indicates the location of the stations and Table 4 presents a description of these stations. The factors which were involved in determining these locations included the total length of time to complete a sampling run and the efficient routing of samples to the laboratory. But the most important factor was the value of the information to be gained by sampling at these locations.

23. The sampling of the stations was divided into two groups: stations #1 through #19 and stations #20 through #29. The first group of stations was sampled from a Rhode Island Division of Fish and Game vessel which was berthed at Wickford, R. I. The stations were sampled in their numbered order. Samples from the latter group of stations were collected from a boat which left from the Edgewood Yacht Club and sampled the stations in their numbered order.

24. *Sampling of stations #1 through #19* Samples were collected at these stations at five feet below the water surface and five feet up from the Bay bottom by means of a Foerst water sampler. At these 19

TABLE 4

LOCATION OF SAMPLING STATIONS

#1 - In channel east of Can Buoy 1 in Greenwich Bay.
Lat. 41° 40' 16", Long. 71° 24' 00"

#2 - West side of Buoy (FLW)"2A," northwest of Patience Island.
Lat. 41° 39' 39", Long. 71° 22' 26"

#3 - In center of channel east of Buoy (FLG) "7."
Lat. 41° 44' 47", Long. 71° 22' 17"

#4 - In channel, midway between Can Buoy 3 and Buoy (QkFLW) "4."
Lat. 41° 43' 40", Long. 71° 21' 50"

#5 - The intersection of a line from the dock at Longmeadow to Conimicut Light and a line from Conimicut Point to Can Buoy 7.
Lat. 41° 42' 48", Long. 71° 21' 02"

#6 - At edge of channel, east of Conimicut Light.
Lat. 41° 43' 02", Long. 71° 20' 39"

#7 - The intersection of a line from Conimicut Point to smokestack east of Nayatt Point and a line from Nayatt Point to Nun Buoy 30.
Lat. 41° 43' 12", Long. 71° 20' 16"

#8 - In channel, west side of Buoy (FLR) "28."
Lat. 41° 42' 15", Long. 71° 19' 43"

#9 - The intersection of a line from the dock just south of Rocky Point to Buoy (FLW) "9" and a line from Nun Buoy 22 to Conimicut Light.
Lat. 41° 41' 38", Long. 71° 19' 38"

#10- East side of Can Buoy 3 at Rumstick Point.
Lat. 41° 42' 15", Long. 71° 17' 55"

TABLE 4
(Continued)

#11 - The intersection of a line from Warwick Light to Nun Buoy 22 and the extension of a line from the dock just south of Rocky Point through Providence Point Buoy.
Lat. 41° 10' 15", Long. 71° 20' 29"

#12 - The intersection of a line from Warwick Light to Nun Buoy 22 and the extension of a line from Buoy (FLW) "9" through Bell Buoy at Ohio Ledge.
Lat. 41° 40' 22", Long. 71° 19' 25"

#13 - On a line from Warwick Light to Nun Buoy 22 just west of Nun Buoy 22.
Lat. 41° 40' 27", Long. 71° 18' 40"

#14 - Intersection of a line from Buoy (FLR) "16" to pier at Homestead, R. I. and the extension of a line from Bell Buoy REF and Nun Buoy 20.
Lat. 41° 37' 06", Long. 71° 17' 42"

#15 - In channel, just west of Buoy (FLR) "16."
Lat 41° 37' 06", Long. 71° 17' 00"

#16 - Centerline of Mount Hope Bridge.
Lat. 41° 38' 24", Long. 71° 15' 30"

#17 - In channel, east side of Can Buoy "3A."
Lat. 41° 40' 06", Long. 71° 13' 30"

#18 - East side of Can Buoy 13.
Lat. 41° 38' 54", Long. 71° 12' 54"

#19 - In channel, west side of Nun Buoy 12.
Lat. 41° 42' 00", Long. 71° 10' 57"

TABLE 4
(Continued)

#20 - In providence River channel, midway between Can Buoy 21 and Nun Buoy 22.
Lat. 41° 47' 21", Long. 71° 22' 41"

#21 - The intersection of a line from Harbor function Wharf to Nun Buoy 24 and a line from State Pier to prominent pier on east shore.
Lat. 41° 48' 19", Long. 71° 23' 33"

#22 - Midway across mouth of Providence River at Fox Point.
Lat. 41° 48' 49", Long. 71° 24' 03"

#23 - Intersection of line from south pier of overhead power cable and spire in Providence and a line from Fox Point to east pier of India Point Swing Bridge.
Lat. 41° 48' 58", Long. 71° 23' 25"

#24 - West side of Nun Buoy 2.
Lat. 41° 49' 21", Long. 71° 23' 13"

#25 - Off north end of center pier of Red Swing Bridge.
Lat. 41° 49' 38", Long. 71° 22' 49"

#26 - In channel, east side of Can Buoy 7.
Lat. 41° 50' 22", Long. 71° 22' 27"

#27 - In channel, east side of Can Buoy 13.
Lat. 41° 50' 47", Long. 71° 22' 24"

#28 - In channel, east side of Can Buoy 17.
Lat. 41° 51' 15", Long. 71° 22' 33"

#29 - In channel, east side of Can Buoy 25.
Lat. 41° 51' 57", Long. 71° 22' 47"

stations, analyses were made of both the top and bottom samples for dissolved oxygen, temperature, MPN and specific conductance. At selected times analyses were also made for biochemical oxygen demand. Analyses for dissolved oxygen and the recording of water temperature were made immediately on the boat. Suitable portions of the sample for the remaining analyses were stored on ice until shipment could be made to the laboratory. In order to verify the accuracy of obtaining samples for coliform organism analysis by means of a standard Foerst water sampler, a number of duplicate samples were run with a sterile sampler. A comparison of the data indicated that there appeared to be no difference between the results obtained by both methods of sampling. A more complete description of this analysis and the results obtained is given in Section I, Appendix B. All samples obtained for MPN analysis were iced and planted within four hours from the time of collection. Each location was sampled at approximately the same time each day with the exception of some weekends. Appropriate note was taken of any unusual occurrences in the area and the wind speed and direction, surface current direction and air temperature were taken at each station during the time of sampling.

25. Sampling of stations #20 through #29 Samples were collected at these stations from three feet below the surface and three feet up from the river bottom. At these ten stations analyses of both top and bottom samples were made for dissolved oxygen, temperature and specific conductance, and at certain selected times analyses were also made for biochemical oxygen demand. On the basis of data collected previously in this area and with a knowledge of the magnitude of the pollution load, it was decided not to sample for coliform organisms at these locations. It was felt that since the MPN was likely to be extremely high in these areas (which was confirmed by the results obtained at station #3), even the most severe effects anticipated as a result of the proposed barriers would not alter the MPN to an extent which would change the present classification of these waters for shellfish taking. Samples were collected at these stations twice each day and for each of the stations at approximately the same time. Again, wind speed and direction, surface current direction and air temperatures were taken at the time of sampling.

26. All samples were analyzed in accordance with Standard Methods.[14] At appropriate points throughout the study area, the samples were collected from the boat sampling crews and transported to a central laboratory

located at the Blackstone Valley Sewage Treatment Plant located at Bucklin Point on the Seekonk River. At the laboratory, two shifts of personnel were required primarily for purposes of the rapid planting and reading necessary for the MPN test.

27. Conditions during the survey Preliminary runs were made around each of the station groups to determine whether they could physically be sampled in the time allotted. The survey then began on June 22 and continued through August 13. Weather conditions during the survey were extremely variable, with periods of relatively heavy precipitation early in the survey with accompanying heavy cloud cover followed by periods of clear skies. The rainfall during the survey period, and the per cent sunshine, both as measured at the Weather Bureau station at the Providence airport, are indicated in Figure 4. Figure 5 presents the wind roses for several stations in the study area. In general, the prevailing winds were from the south south west with average velocities of about 5 mph and gusts up to 30 mph. Although the estimates of wind speeds and directions at the sampling stations are subject to observational errors, the general channeling of the wind up the east passage and into Mount Hope and Upper Narragansett Bays is indicated. These weather parameters are discussed and analyzed further under the Analysis and Interpretation of Data with respect to their effects on water quality.

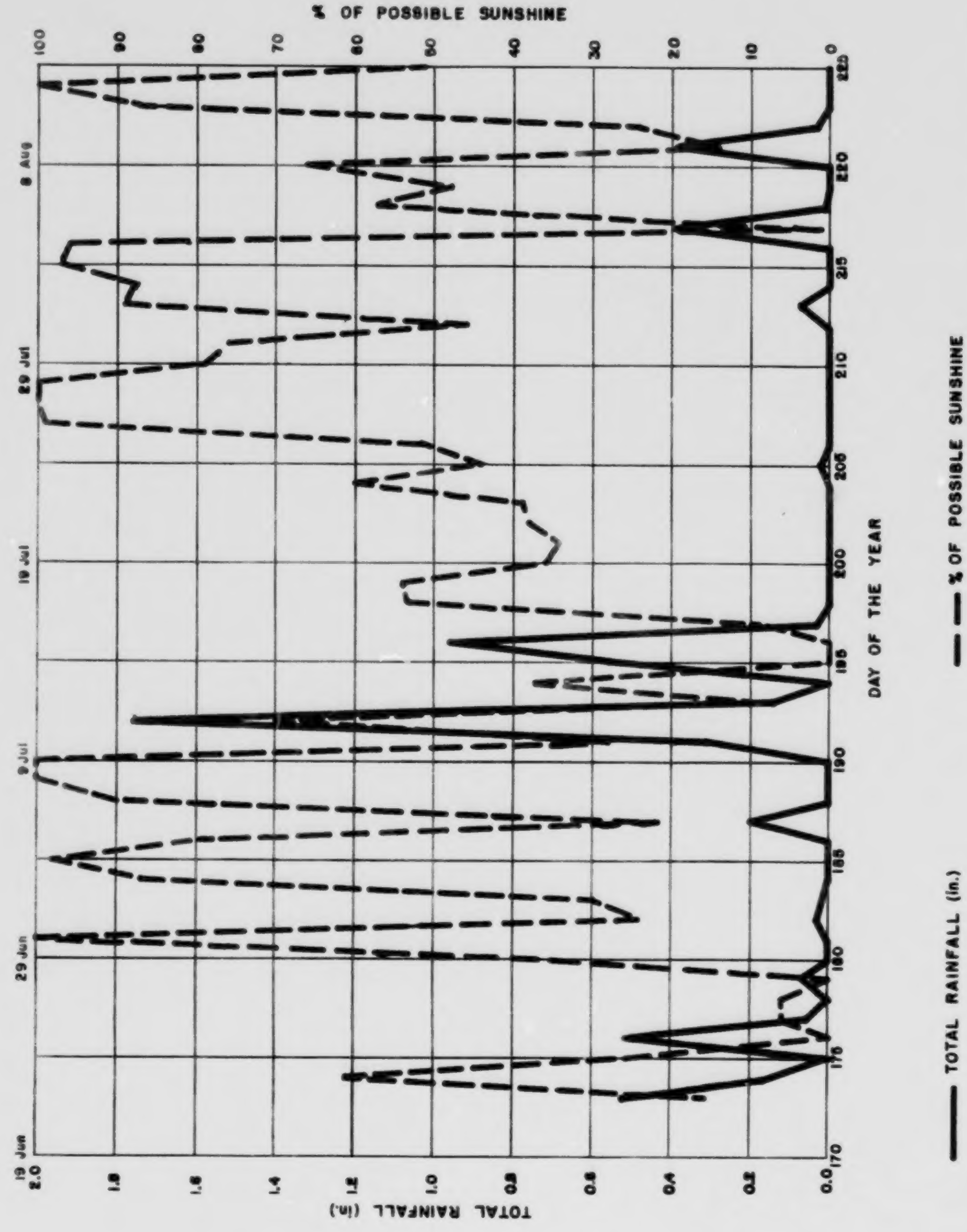
28. Fresh water inflow Figure 6 presents the variation in flow during the survey for the four major streams discharging into the waters of the study area. The effects of regulation on the Taunton, Blackstone and Pawtuxet Rivers can be noted. The absence of any extended period of steady flow complicates the determination of the effects of fresh water flow on the water quality of the study area. Also, because of regualtion on the streams there is little correlation between periods of high rainfall and increased flow as can be seen by comparing Figure 4 with Figure 6. The estimated effect of these flow variations on the data collected during 1959 are discussed under the Analysis and Interpretation of Data.

29. Results of survey The results of the various analyses performed on the samples collected together with other information on climatic conditions at the time of sampling were coded and punched on computer cards for ease of handling and analysis. A print-out of all of the results obtained without the climatic information is presented in Appendix A. These data have been sorted by station number and depth and are

presented in these groupings. An inspection of these results indicates a wide range in values for a given variable. For example, at station #3 - top, the range in dissolved oxygen varied from 1.4 ppm to 11.2 ppm, or almost 10 ppm. Also, for the same station and depth the MPN varied from a low of 2 to a high of 110,000 per 100 ml, the specific conductance varied from 23,700 U mhos (8.0 o/oo chlorides) to 44,600 U mhos (16.5 o/oo chlorides), and the temperature ranged from 17.5°C. to 25.0°C. Although this station represents one of the more extreme examples, the ranges in all variables at the surface of most stations were considerably greater than had been anticipated. Whereas, in general, the variation in the quality variables at the bottom of most stations was somewhat smaller, which had been anticipated. Plots of the quality data in Appendix A, with the time of survey in days, indicated, especially for dissolved oxygen in the Providence and Seekonk Rivers, that there were generally three periods during the survey where mixing occurred from top to bottom and two periods of relatively intense stratification. These periods were not as pronounced for the chloride concentration or for temperature, nor for the more open areas of the Bay, although there still appears to be some degree of mixing. However, for MPN alternating periods of stratification and mixing seem to occur at approximately the same time as for the dissolved oxygen. These periods of mixing within the two month survey altered somewhat the original method of analysis proposed for the interpretation of the data. It had not been suspected that the waters of the area do mix (at least for dissolved oxygen and MPN) to such a large extent. The character of the area, rather than being a two-layered system at all times, appears to alternate between periods of intense stratification and periods of almost complete mixing more frequently than had heretofore been suspected. Figure 7 presents a few examples of this phenomena for dissolved oxygen along the route given by station numbers 3-6-8-13.

30. Table 5 presents a summary of the results obtained. The values presented in this Table represent the average conditions during the period of the survey. As mentioned previously, considerable variations occurred during the survey and the analysis of the results as discussed below serves to document and explain these variations. For purposes of initial orientation and since most of the average values given in Table 5 are used in the interpretation of the data, Figures 8, 9, 10 and 11 present the average isopleths of the variables for both surface and bottom.

31. The surface biochemical oxygen demand values were not given any significant interpretation due to the presence of algae in many of the



EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

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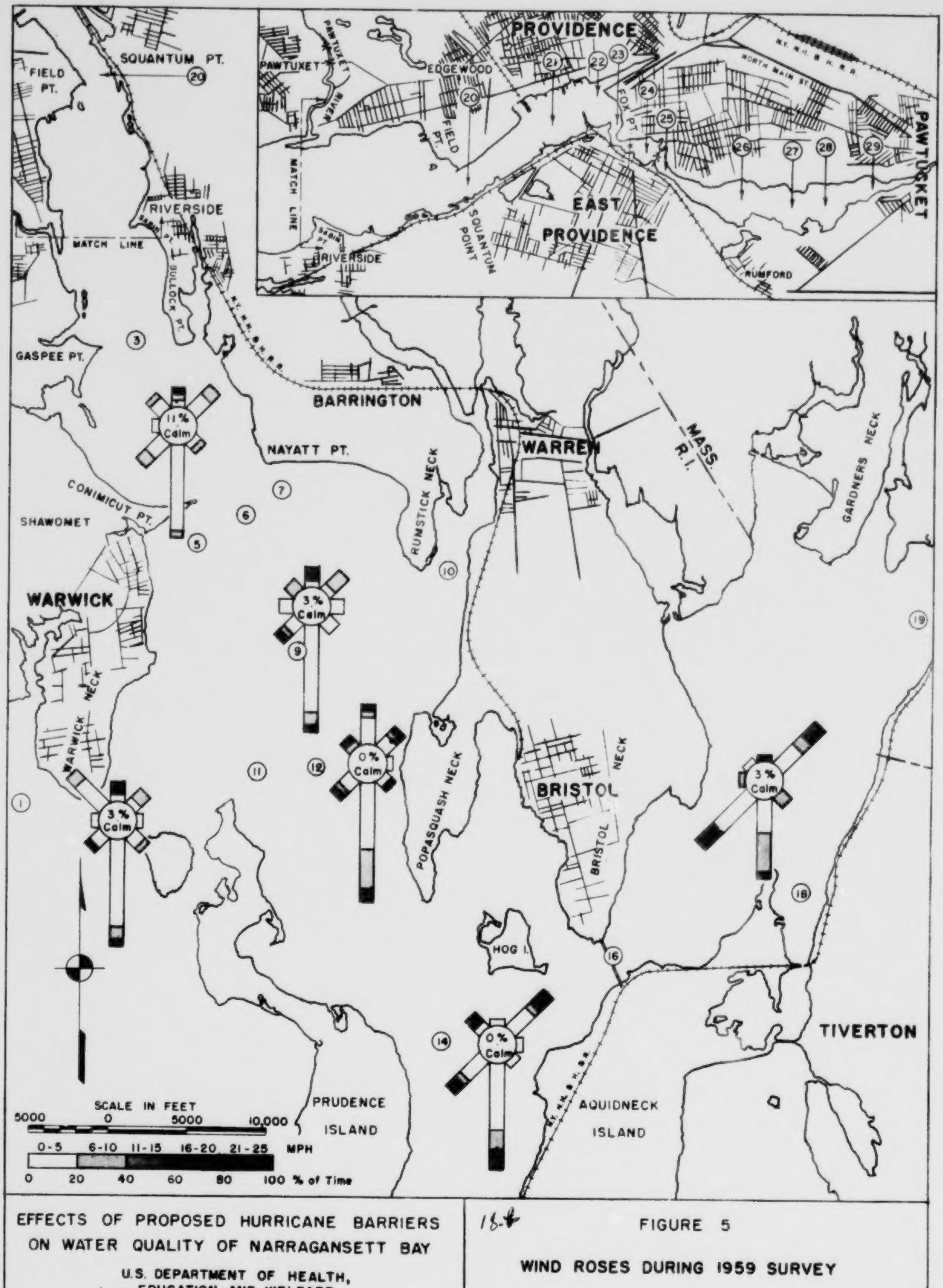
EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

18-a

FIGURE 4
TOTAL RAINFALL AND
% OF POSSIBLE SUNSHINE
DURING 1959 SURVEY



PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
PAWTUCKET
MATCH LINE
SQUANTUM POINT
EAST PROVIDENCE
SABIN PT.
RIVERSIDE
RUMFORD
FIELD PT.
SQUANTUM PT.
MATCH LINE
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
WARWICK
WARWICK NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
11% Calm
3% Calm
0% Calm
3% Calm
3% Calm
0% Calm
1
3
5
6
7
9
10
11
12
14
16
18
19
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21
22
23
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25
26
27
28
29
SCALE IN FEET
5000 0 5000 10,000
0-5 6-10 11-15 16-20 21-25 MPH
0 20 40 60 80 100 % of Time

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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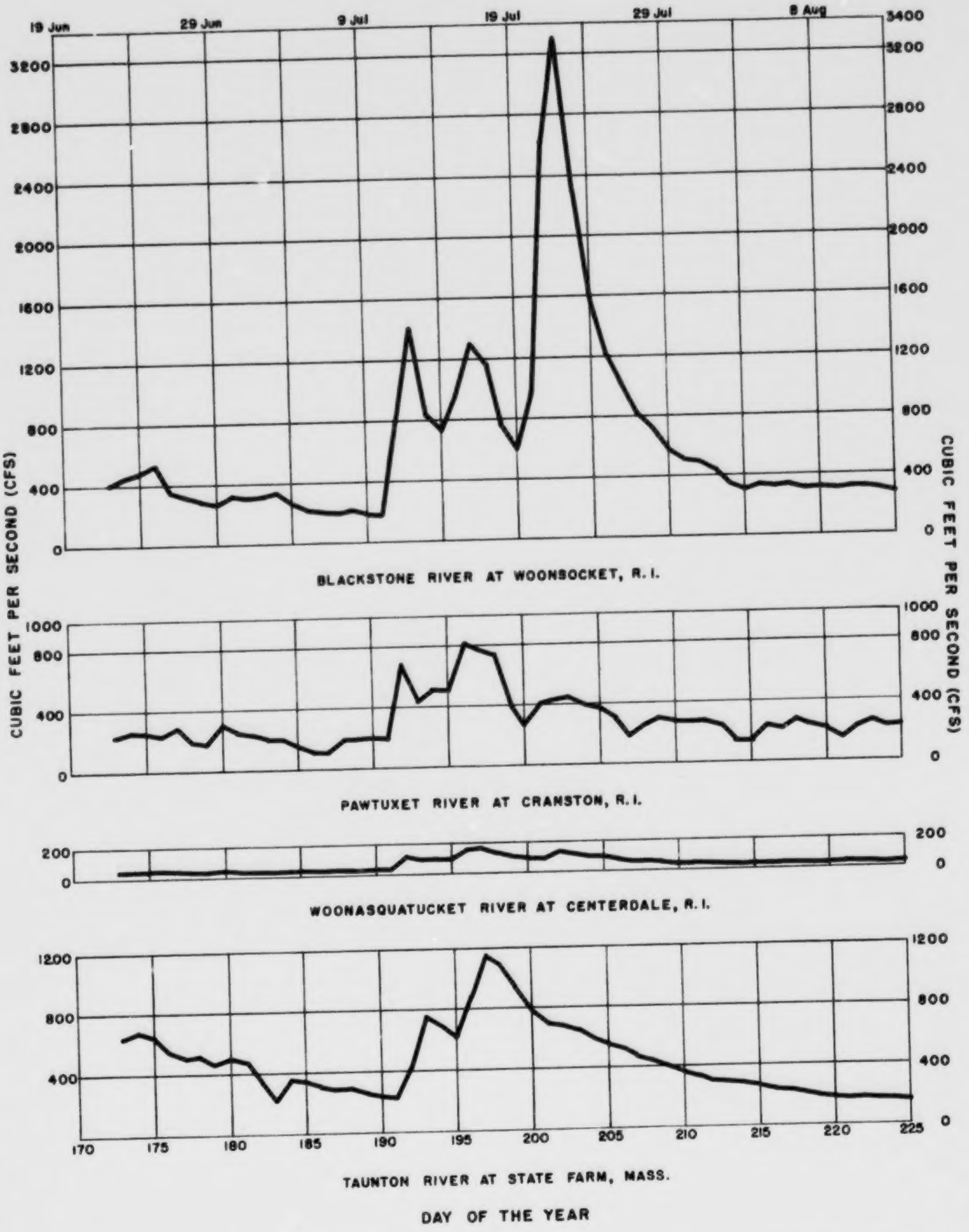
PUBLIC HEALTH SERVICE

18-4

FIGURE 5

WIND ROSES DURING 1959 SURVEY



BLACKSTONE RIVER AT WOONSOCKET, R.I.

PAWTUXET RIVER AT CRANSTON, R.I.

WOONASQUATUCKET RIVER AT CENTERDALE, R.I.

TAUNTON RIVER AT STATE FARM, MASS.

DAY OF THE YEAR

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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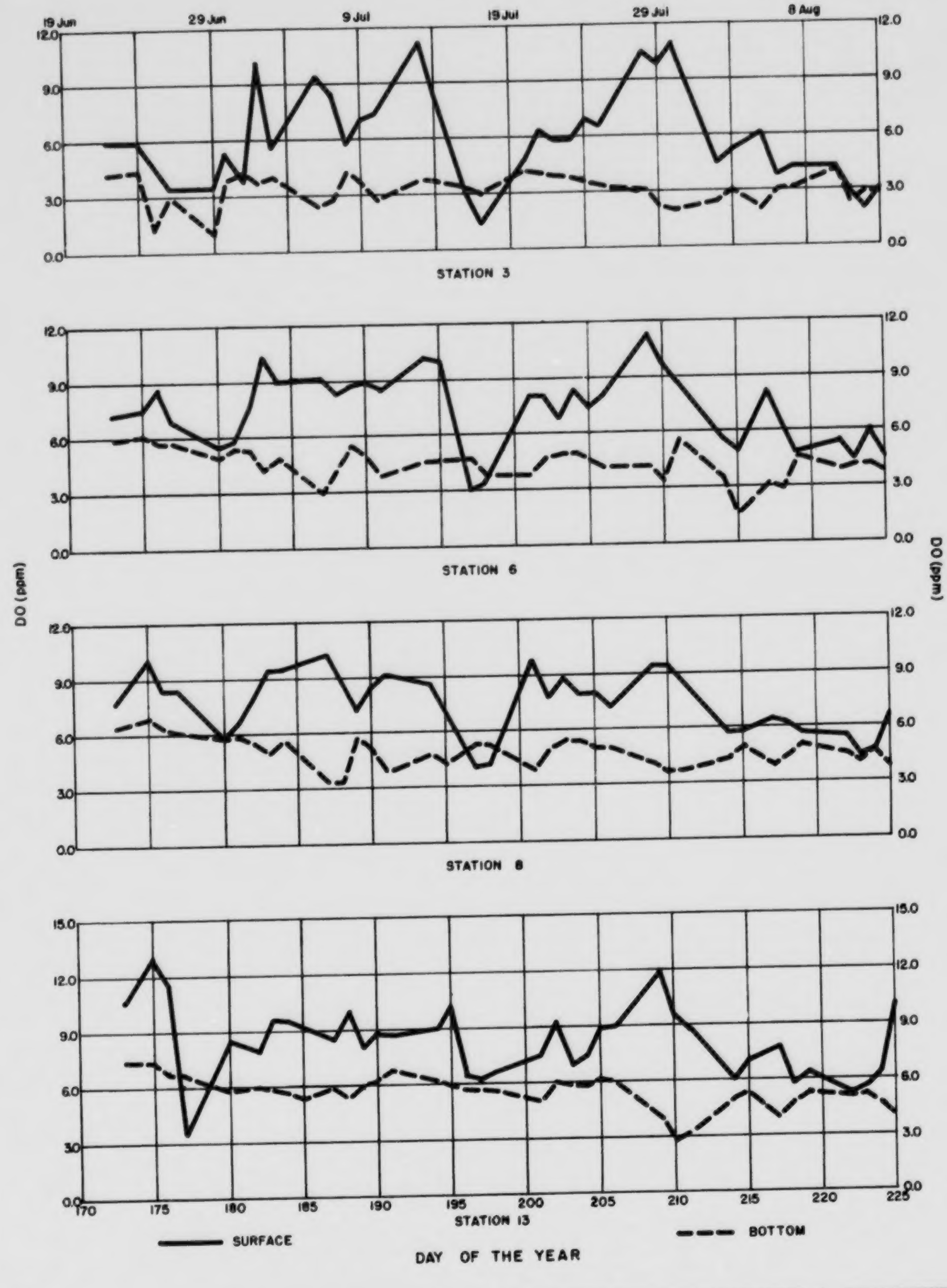
PUBLIC HEALTH SERVICE

18-C

FIGURE 6
FRESH WATER INFLOW
DURING 1959 SURVEY

DATA COURTESY OF U.S. GEOLOGICAL SURVEY



EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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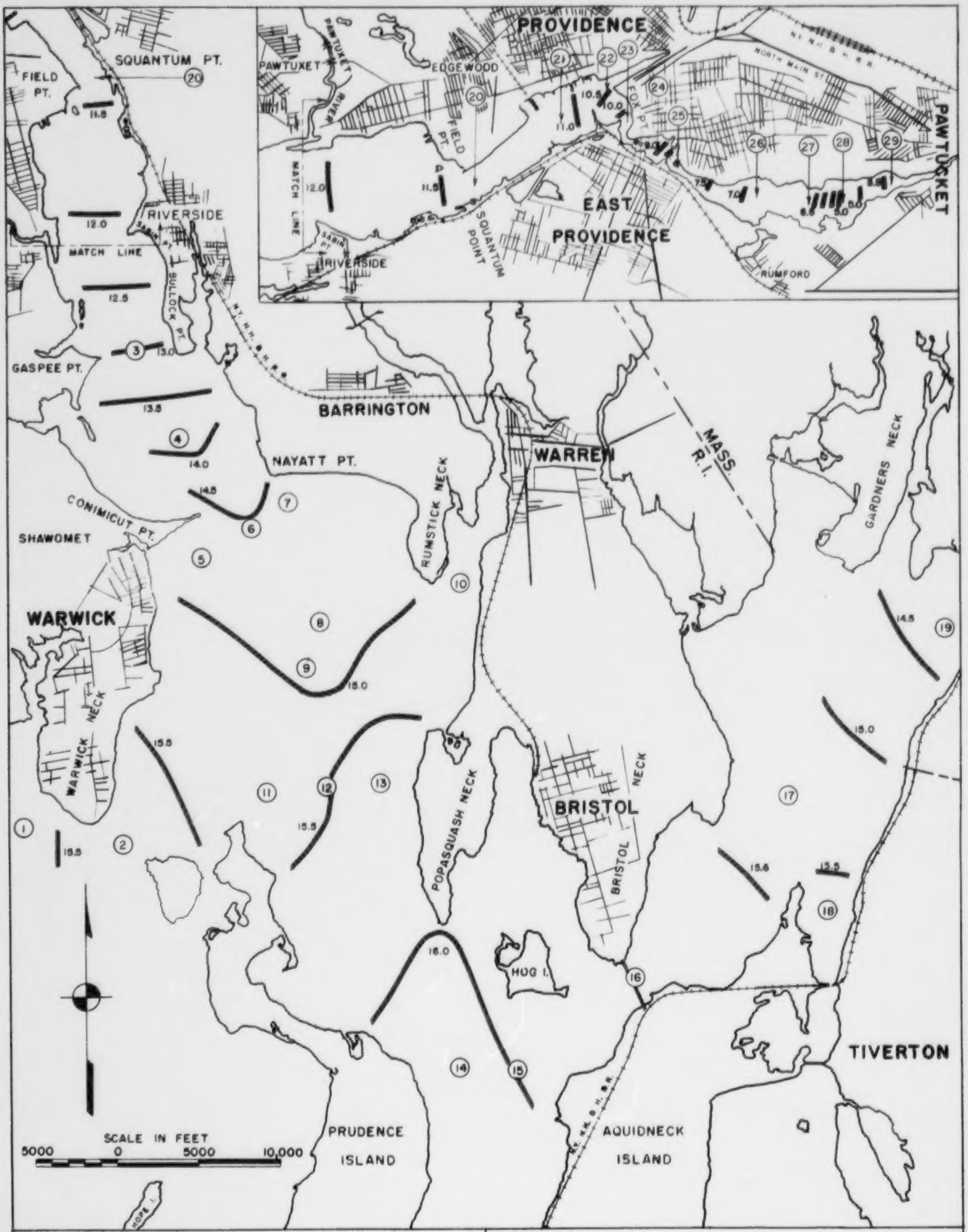
PUBLIC HEALTH SERVICE

18-d

FIGURE 7
DISSOLVED OXYGEN
VARIATIONS
DURING 1959 SURVEY


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
PAWTUCKET
MATCH LINE
RIVERSIDE
SABIN PT.
SQUANTUM POINT
EAST PROVIDENCE
RUMFORD
SQUANTUM PT.
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
SCALE IN FEET
5000 0 5000 10,000
11.0
10.5
10.0
11.5
12.0
12.5
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14.0
14.5
15.0
15.5
16.0
7.0
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EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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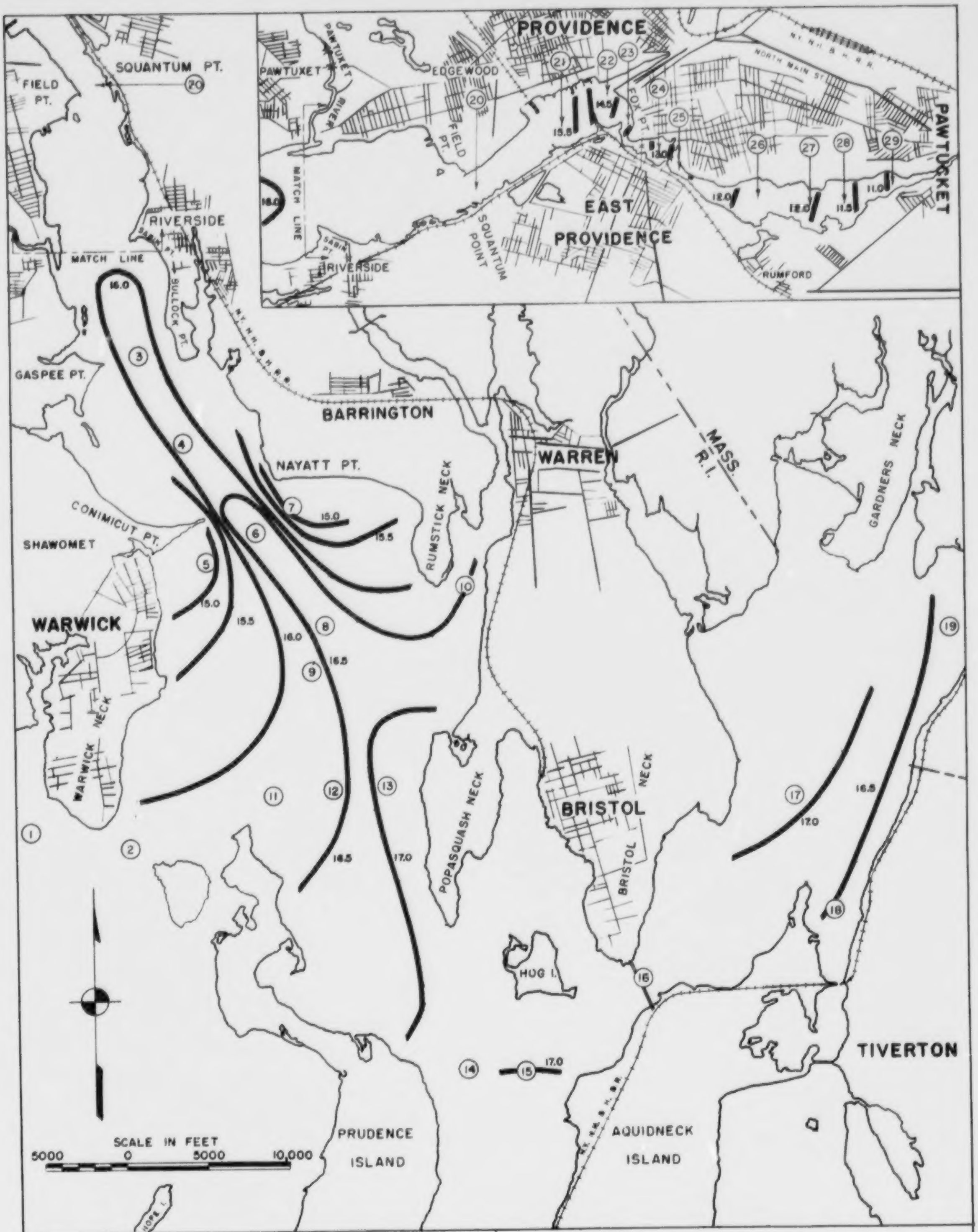
PUBLIC HEALTH SERVICE

18-2

FIGURE 8
AVERAGE ISOCHLORS (‰)
DURING 1959 SURVEY

SURFACE


PROVIDENCE
PAWTUCKET
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
EAST PROVIDENCE
SQUANTUM POINT
MATCH LINE
SABIN PT.
RIVERSIDE
RUMFORD
SQUANTUM PT.
FIELD PT.
GASPEE PT.
BULLOCK PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
SCALE IN FEET
5000 0 5000 10,000
16.0
15.0
15.5
16.5
17.0
15.8
14.0
13.0
12.0
11.5
11.0
① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪ ⑫ ⑬ ⑭ ⑮ ⑯ ⑰ ⑱ ⑲ ⑳ ㉑ ㉒ ㉓ ㉔ ㉕ ㉖ ㉗ ㉘ ㉙

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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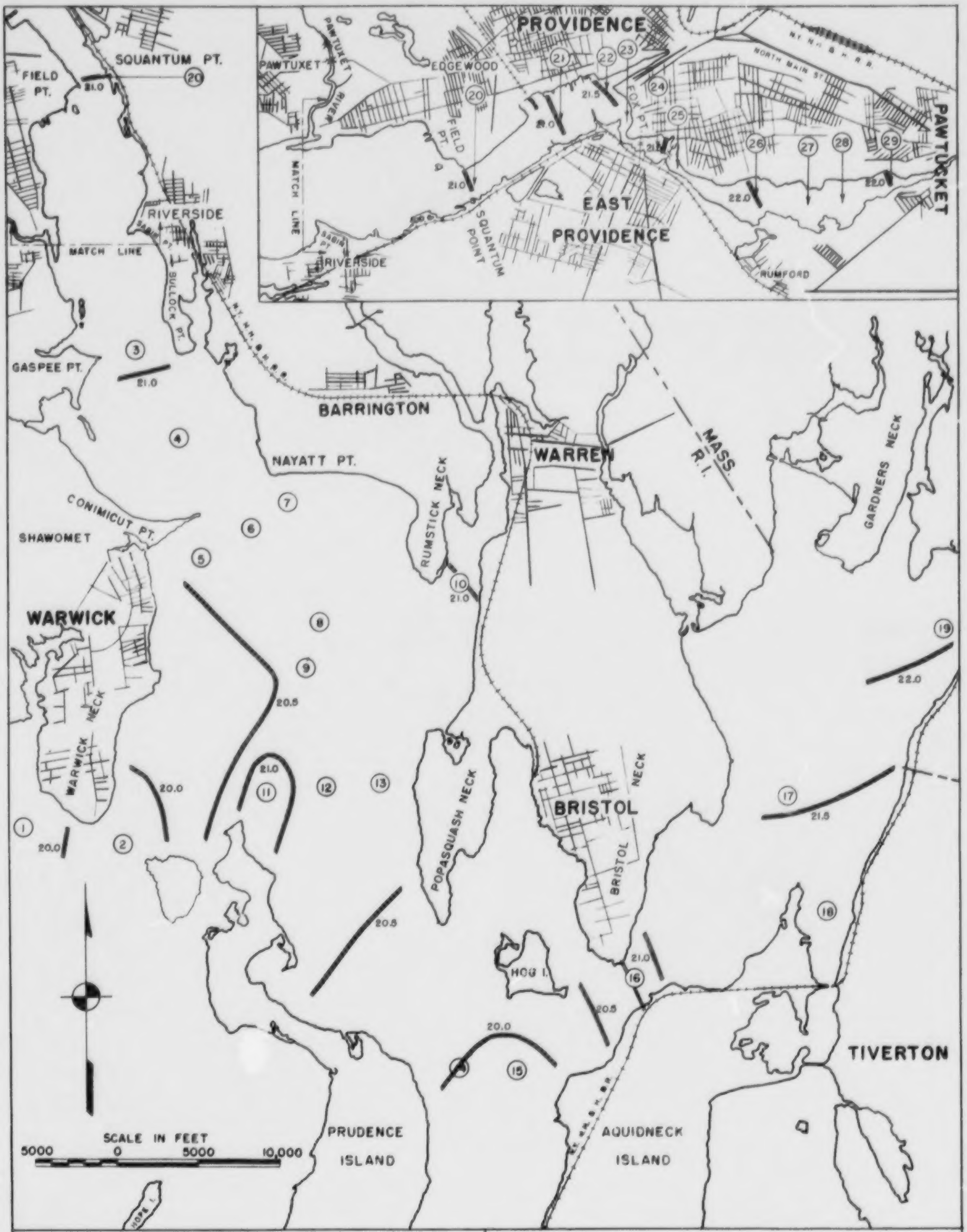
18-f

FIGURE 8
AVERAGE ISOCHLORS (‰)
DURING 1959 SURVEY

BOTTOM


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
PAWTUCKET
EAST PROVIDENCE
SQUANTUM POINT
SABIN PT.
RIVERSIDE
RUMFORD
MATCH LINE
N.Y. N.H. & H. R.R.
21
22
23
24
25
26
27
28
29
20
21.0
21.5
22.0
FIELD PT.
SQUANTUM PT.
RIVERSIDE
MATCH LINE
SABIN PT.
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20.0
20.5
21.0
21.5
22.0
SCALE IN FEET
5000
0
5000
10,000

EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

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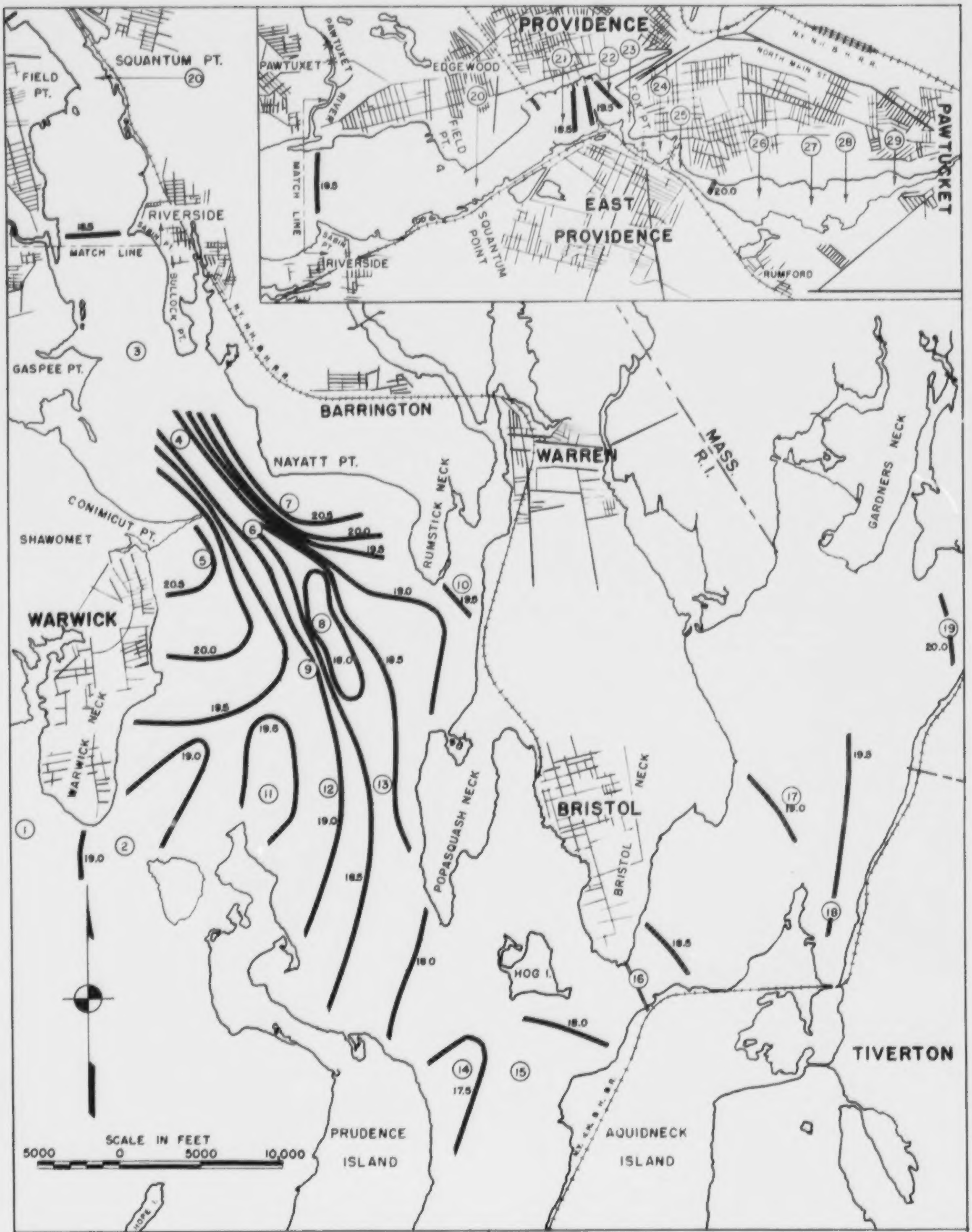
PUBLIC HEALTH SERVICE

18-9

FIGURE 9
AVERAGE ISOTHERMS (°C)
DURING 1959 SURVEY

SURFACE


PROVIDENCE
EAST PROVIDENCE
PAWTUCKET
PAWTUXET
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
PAWTUXET RIVER
MATCH LINE
SQUANTUM POINT
RIVERSIDE
RUMFORD
N.Y. N.H. & H. R.R.
SQUANTUM PT.
FIELD PT.
RIVERSIDE
SABIN PT.
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
SCALE IN FEET
5000 0 5000 10,000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
20.5
20.0
19.5
19.0
18.5
18.0
17.5

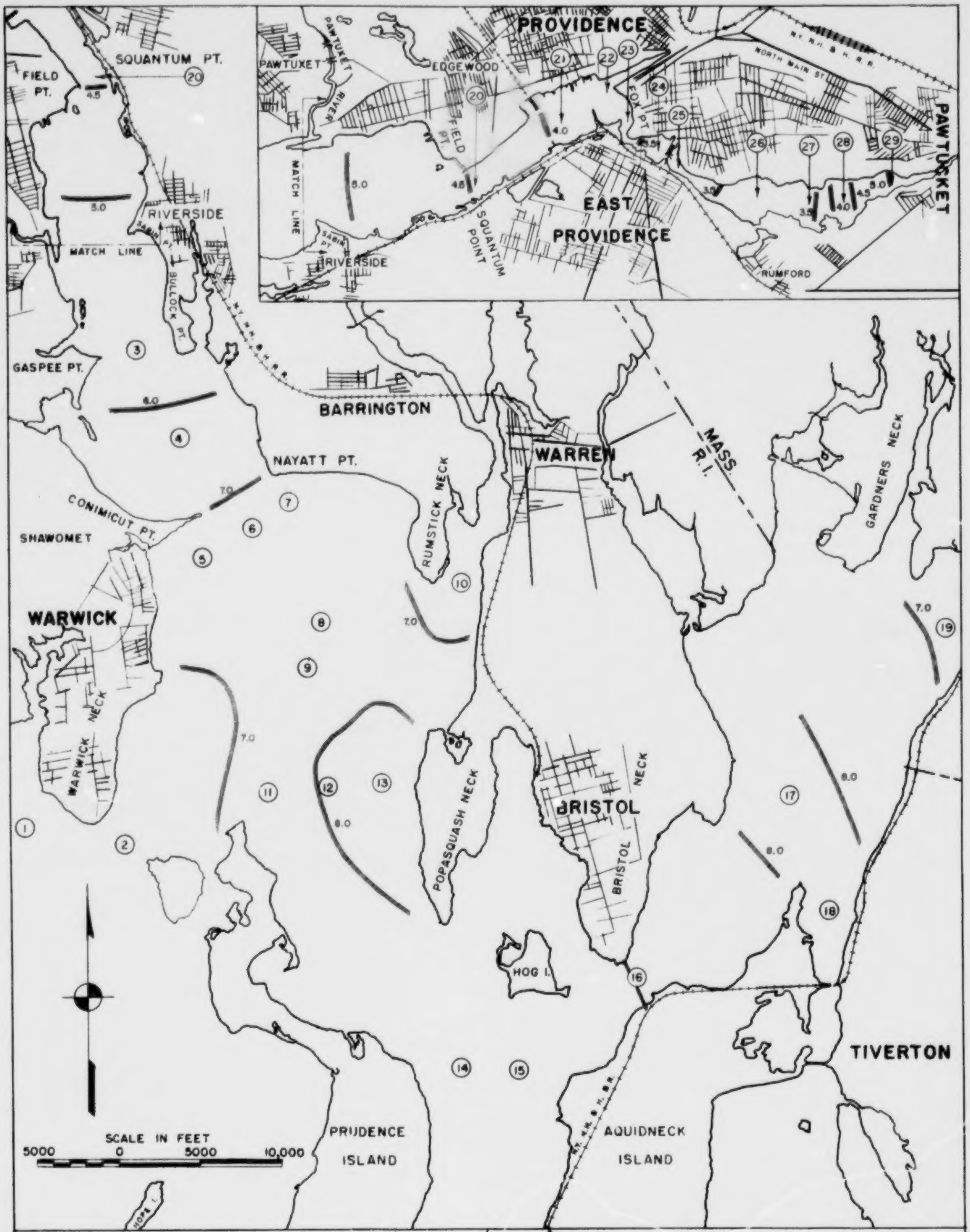
EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

U.S. DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

18-k

FIGURE 9
AVERAGE ISOTHERMS (°C)
DURING 1959 SURVEY

BOTTOM

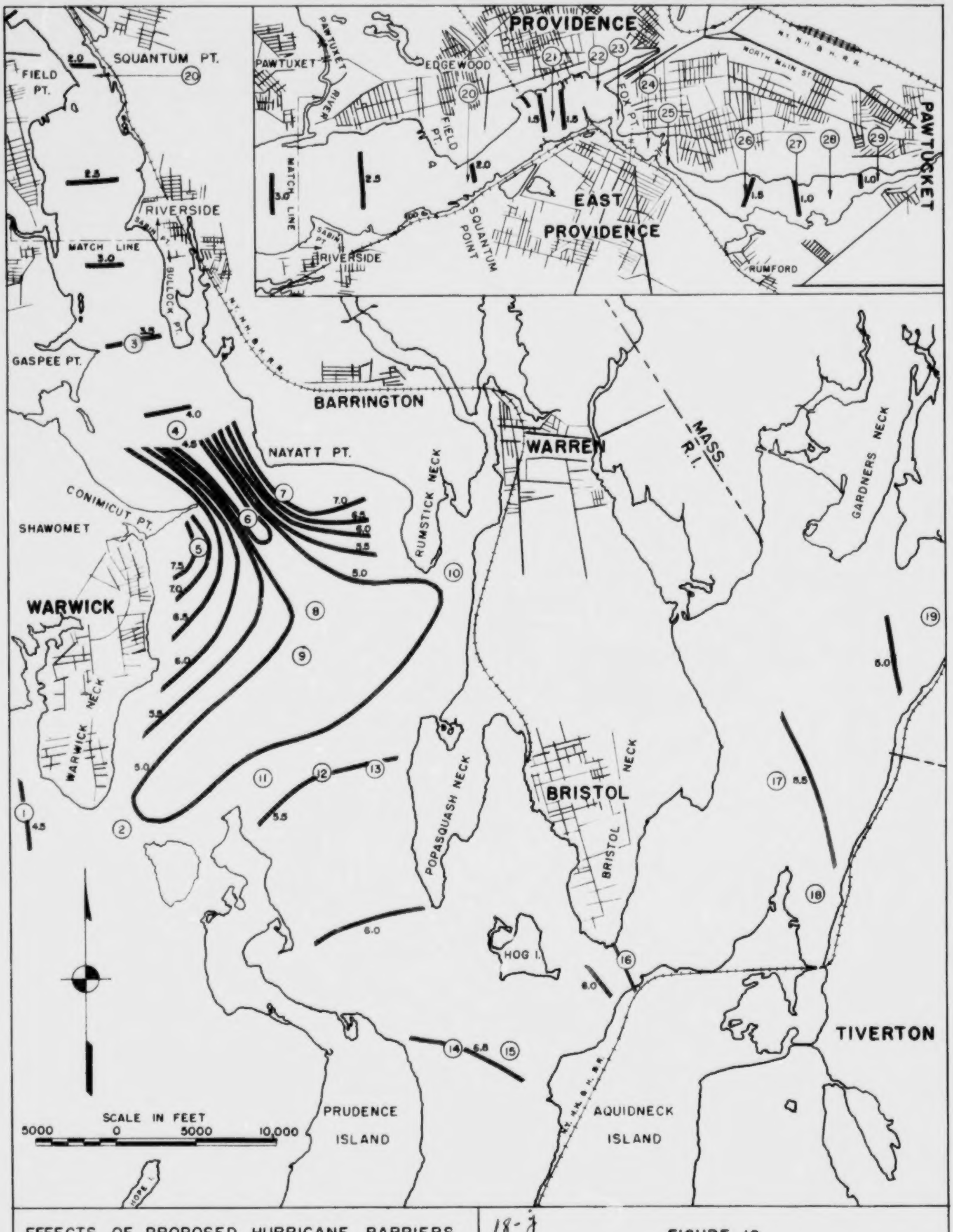

PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
N.Y. N.H. & H. R.R.
NORTH MAIN ST.
PAWTUCKET
MATCH LINE
SABIN PT.
RIVERSIDE
SQUANTUM POINT
EAST PROVIDENCE
RUMFORD
20
21
22
23
24
25
26
27
28
29
4.0
4.8
3.5
4.5
5.0
SQUANTUM PT.
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARREN
RUMSTICK NECK
MASS.
R.I.
GARDNERS NECK
WARWICK
WARWICK NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
6.0
7.0
8.0
SCALE IN FEET
5000 0 5000 10,000

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

U.S. DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

18-2

FIGURE 10
AVERAGE DISSOLVED OXYGEN ISOPLETHS
(ppm) DURING 1959 SURVEY
SURFACE


PROVIDENCE
EAST PROVIDENCE
PAWTUCKET
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
RUMFORD
SQUANTUM POINT
SQUANTUM PT.
RIVERSIDE
SABIN PT.
BULLOCK PT.
MATCH LINE
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
N.Y. N.H. & H. R.R.
SCALE IN FEET
5000 0 5000 10,000
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
6.8
7.0
7.5
8.0
8.5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

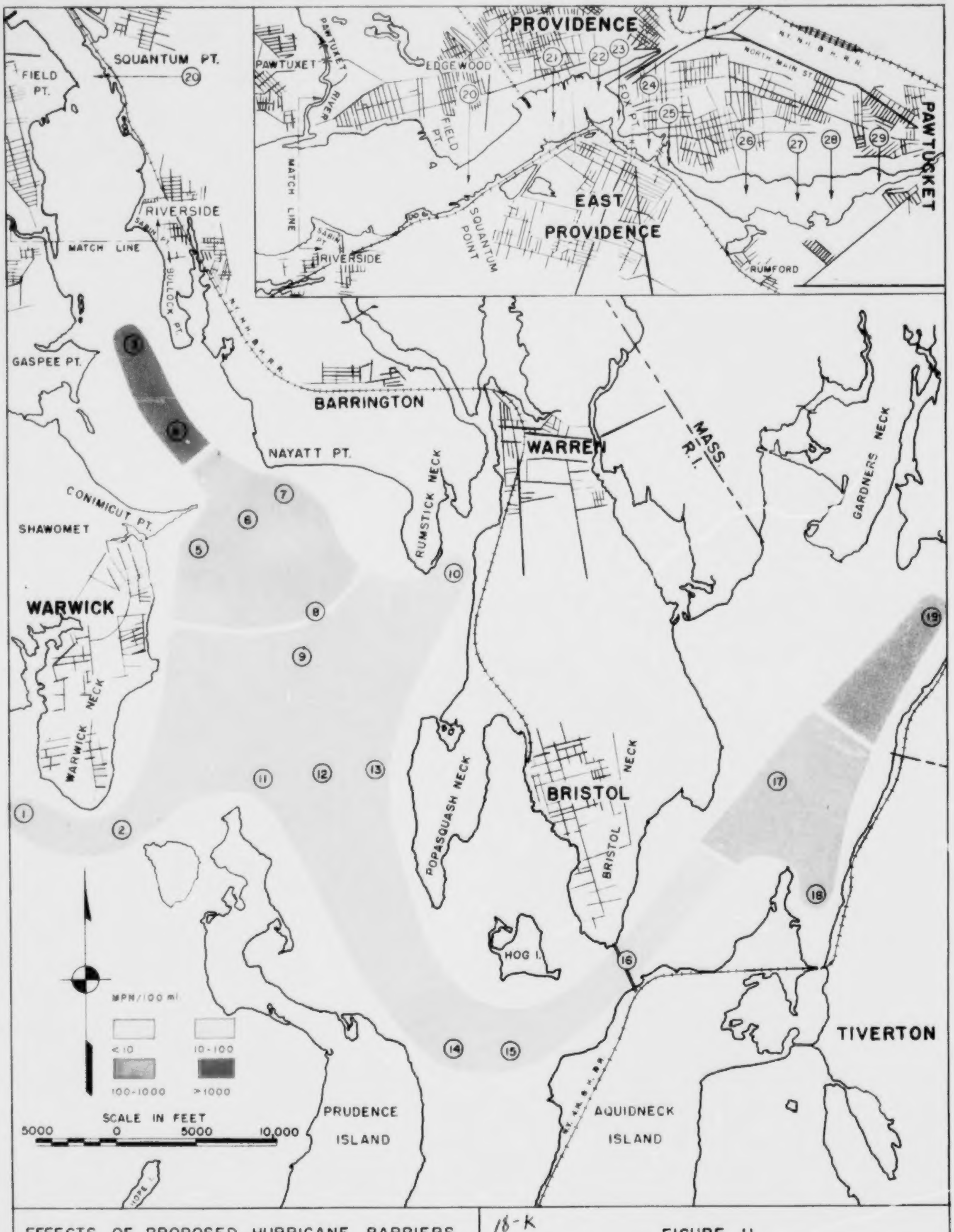
U.S. DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

18-j

FIGURE 10

AVERAGE DISSOLVED OXYGEN ISOPLETHS (ppm) DURING 1959 SURVEY

BOTTOM


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
PAWTUCKET
MATCH LINE
EAST PROVIDENCE
SQUANTUM POINT
RIVERSIDE
SABIN PT.
RUMFORD
21
22
23
24
25
26
27
28
29
20
FIELD PT.
SQUANTUM PT.
RIVERSIDE
SABIN PT.
MATCH LINE
BULLOCK PT.
N.Y. N.H. & H. R.R.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
MPN/100 ml
<10
10-100
100-1000
>1000
SCALE IN FEET
5000
0
5000
10,000

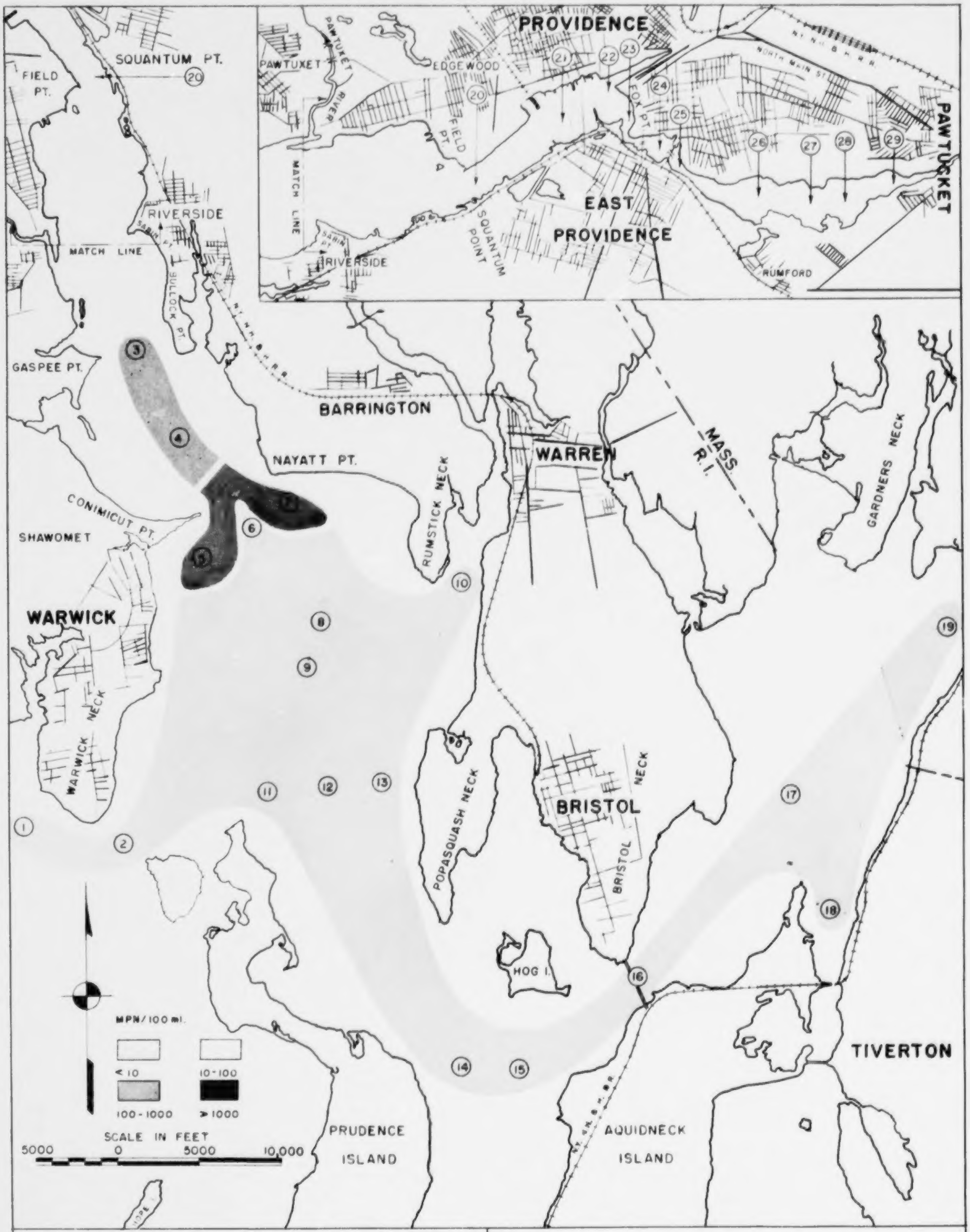
EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

18-K

FIGURE 11
AVERAGE MPN/100ml. ISOPLETHS DURING 1959 SURVEY

SURFACE


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
MATCH LINE
FOX PT.
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
PAWTUCKET
EAST PROVIDENCE
SQUANTUM POINT
RIVERSIDE
SABIN PT.
RUMFORD
SQUANTUM PT.
RIVERSIDE
MATCH LINE
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
BRISTOL
HOG I.
PRUDENCE ISLAND
AQUIDNECK ISLAND
TIVERTON
HOPE I.
MPN/100 ml.
< 10
10-100
100-1000
> 1000
SCALE IN FEET
5000
0
5000
10,000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
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27
28
29

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

U.S. DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

18-2

FIGURE 11
AVERAGE MPN/100ml. ISOPLETHS
DURING 1959 SURVEY

BOTTOM

TABLE 5

AVERAGE QUALITY CONDITIONS DURING 1959 SURVEY

Station Number	Dissolved Oxygen (ppm)		Temperature (°C.)		Most Probable Number* (per 100 ml)		Chlorides (o/oo)	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
1	6.7	4.5	20.4	19.4	20	10	15.3	16.1
2	6.5	5.0	19.7	18.8	50	15	15.8	16.4
3	5.7	3.5	21.2	18.6	2260	210	13.0	16.1
4	6.1	4.1	20.8	18.6	1910	105	13.8	16.2
5	7.5	-	20.7	-	260	-	14.8	-
6	7.3	4.4	20.7	18.5	380	60	14.5	16.8
7	7.4	-	20.8	-	230	-	14.8	-
8	7.4	4.8	20.6	17.8	180	30	14.8	16.6
9	7.7	4.7	20.6	19.3	80		14.9	16.4
10	6.8	5.0	21.0	19.7	80	20	15.1	16.5
11	7.5	5.4	21.1	19.7	40	20	15.2	16.3
12	8.1	5.5	20.8	19.2	70	20	15.5	16.3
13	8.2	5.5	20.8	18.5	45	10	15.7	17.3
14	7.6	6.5	20.0	17.4	25	10	16.3	17.2
15	7.3	6.3	19.8	17.7	40	15	16.0	17.0
16	7.7	5.9	20.9	18.4	45	10	15.7	16.7
17	8.2	5.6	21.8	19.1	140	15	15.3	17.2
18	8.1	5.6	21.0	19.5	140	50	15.6	16.2
19	6.8	4.8	22.1	20.0	1240	90	14.2	16.3
20	4.5	2.0	21.0	18.3	-	-	11.3	15.8
21	3.9	1.4	21.0	18.3	-	-	11.3	15.9
22	3.6	1.8	21.9	19.7	-	-	10.7	14.7
23	3.6	1.8	21.4	19.4	-	-	9.9	14.0
24	3.4	1.8	21.4	19.8	-	-	9.1	13.4
25	3.6	1.7	21.7	19.9	-	-	7.7	12.6
26	3.3	1.5	22.0	20.2	-	-	6.9	11.7
27	3.4	1.1	22.1	20.2	-	-	6.8	12.0
28	4.4	0.9	22.2	20.4	-	-	4.8	11.6
29	5.0	1.1	22.0	20.4	-	-	5.6	10.8

*Geometric Average

samples. This is evidenced by the supersaturated dissolved oxygen conditions observed in conjunction with relatively high BOD values. For example at the surface of stations #11, 12, and 13 it appears that a considerable amount of pollutional material is present although there is no evidence of significant pollutional discharges in the area of these stations. Further, the surface dissolved oxygen content at these stations is consistently high and is often in a supersaturated condition. Hence, the "high" BOD values at the surface of most stations in the open area of the Bay indicates the presence of large amounts of algae. When these plants are trapped in a sample and incubated they are usually no longer able to survive and thereby contribute to a much higher BOD value. Likewise supersaturated conditions were often observed even in the more polluted areas of the Providence and Seekonk Rivers indicating that even these surface BOD values are not truly representative of conditions in the Rivers. The BOD values for the bottom layers which are not subjected to photosynthetic action are more truly representative of amounts of oxidizable material. However, Table 5 indicates that for all stations from #1 to #19 the BOD values are in a relatively low range such that any interpretation made is difficult and doubtful. Probably the only values which are truly representative of oxidizable organic pollution load are those observed at the bottom of stations 21, 22, 23, 26 and 28. It was for the above reasons that the sampling of the waters for biochemical oxygen demand was curtailed after the first two weeks of the field study. It was felt that the amount of effort and time required to analyze samples for BOD was not worth the value of the interpretation which could be placed on the results. Since only very limited interpretation can be placed on the BOD values, the isopleths for this variable are not presented and reference will be made to the BOD results only in connection with discussions on the quality of the Providence and Seekonk Rivers.

32. Since samples were not collected at the bottom at stations #5 and #[illegible], due to the shallow depth, the isopleths for the surface and bottom include the same values for these stations. It was felt that this was reasonable for these stations since the samples were collected at essentially mid-depth (for an average depth of about 10 feet) and on the basis of previous sampling it was not anticipated that any large degree of stratification occurs in these flats. All figures depicting lines of equal value were drawn independently of each other and without reference to any other material such as depth or current charts.

33. Some general observations can be made by examining the isochlors presented in Figure 8. The degree of vertical stratification is greater in the Providence and Seekonk Rivers and Mount Hope Bay than in the rest of the study area. The largest degree of average vertical stratification occurred at station #28 where a difference of about 6.8 o/oo Cl was observed. Likewise, the degree of longitudinal stratification increases in the Providence River and Mount Hope Bays at both the surface and bottom. Lateral stratification at the surface is small, but at the bottom of Upper Narragansett Bay appears to be somewhat greater. Probably the most significant aspect of these plots is the general tendency of the surface waters to flow in the seaward direction (as a result of incoming fresh water) and the tendency of the bottom waters to flow in a flooding direction. Although it is difficult to ascertain the direction for the surface and bottom from stations #11, 12 and 13 to #14 and 15 the flow appears to flood uniformly along the western end of Popasquash Neck and conversely appears to ebb along the eastern end of Prudence Island. This probably results in a lateral current gradient in this channel. The isochlors for Mount Hope Bay tend to show a general flooding along the bottom resulting primarily from the East Passage and a general ebbing along the surface.

34. The sketch of the average isotherms as shown in Figure 9 indicates somewhat the same pattern as discussed above. In this case, however, the net seaward flow on the surface is not so readily apparent. For the surface there does not appear to be a marked longitudinal temperature gradient for the area as a whole. Vertical stratification is almost uniform averaging about 2-2.5°C. The channeling of flow in the East Passage, at least along the bottom, is indicated by the intrusion of lower temperature water in this area. There appears to be a general flooding from station #2 into Upper Narragansett Bay although this is not too obvious from the isochlors. The occurrence at station #2 of relatively low surface temperatures, relatively high surface chloride concentration and, as can be seen in Figure 10, relatively low dissolved oxygen concentration, indicates the possible presence of upwelling due to predominately divergent currents. Inspection of the current data collected by other investigators and mentioned previously herein indicates that this may be the case.

35. The dissolved oxygen and MPN plots are more diffuse probably due to the inherent characteristics of these variables. Both of these variables are subject to biological and bacteriological influences, in

additional to the factors which influence chlorides and temperature. Being such, they are less reliable indicators of water movement.

36. For dissolved oxygen, the degree of vertical stratification increase in the Providence and Seekonk Rivers with a maximum average stratification of 4.0 ppm occurring at station #29. Longitudinal dissolved oxygen stratification for the surface and bottom is also greatest in the Providence and Seekonk Rivers. Later stratification in Upper Narragansett Bay is relatively small. In general, however, it can be seen from Figure 10 that the surface and bottom layers differ markedly in magnitude and distribution of dissolved oxygen.

37. Due to the relatively large variability of the MPN test itself, identifiable isopleths are not plotted; rather, areas of MPN range are indicated. The MPN plot indicates the difference in this quality variable from that of dissolved oxygen. It can be noted that the greatest MPN values exist in the surface layers. For the geometric average conditions, the bottom layers were in the range of 10-100 MPN/100 ml with the exception of the lower end of Mount Hope Bay. For the surface the 100-1000 MPN range extends out into the Upper Bay as far as stations #8 and #9 and for Mount Hope Bay extends a considerable distance below station #17. Whether this pattern again indicates predominately divergent flow directions between the surface and bottom is not quite clear, since higher surface MPN counts would be due in part to the "floating" action of coliform bacteria in sewage.

38. All of the plots discussed above represent the average conditions during the survey. They do not include the time element which provides an indication of the changes in quality during a tidal cycle or from day to day. Being averages, the values include the effects of the diverse meteorological conditions which occurred during the survey and which have been discussed previously; nor do average conditions provide reliable means for determining the causes of the variations observed in line with the objectives of this report. These are the purposes of the discussion which follows.

Analysis and Interpretation of Data

39. General The characteristics of water which determine its suitability for different uses are functions of many environmental factors. Most water quality characteristics are affected mainly by the

following environmental facotrs: the pollution load discharged, the fresh water inflow into the system, the variations in tidal currents and tidal heights, wind, rain and, in some cases, amount of sunshine. For purposes of this report, interest is centered primarily around the effects of changes in tidal currents and heights on a particular water quality characteristic. Briefly, then, the problem consists of the separation of the effects of the tidal regime on a water quality variable. If this can be done with a reasonable degree of accuracy, the effects on water quality of the changes in the tidal regime which might be occasioned by the proposed barriers can be determined.

40. Methodology In the analysis of the data collected for this study, the approach consists of the following steps:

a) Relating the changes in water quality to time
b) Relating the changes in the environmental factors which may affect water quality to the came time periods used in (a)
c) Determining the causative interrelationships between (a) and (b) using time as the independent variable
d) Determining the separate quantitative effects of the tidal regime on a water quality variable.

41. The first two steps above provide a description in time of the changes in either a quality variable or in an environmental factor. This can be done using various mathematical and statistical tools which relate any variable to a time series. A time series for this purpose may be considered as any particular length of time, where the starting point in the time dimension is uniquely determined. For example, in the time series related to the tidal phenomena of about 12 hours, the zero or starting point in the time dimension is taken as the time of last high water prior to the time the sample was taken. Hence, all the samples are referred in the tidal time dimension to a common zero point. Similarly, with regard to the so-called annual time dimension, i. e. throughout a year, the samples collected are positioned in this time scale with respect to the first day of the year (January 1) as the starting point. Other time series may be used depending on the particular phenomena involved or the specific purposes for which the study is being made. If the water quality characteristics or environmental factors can accurately be related to the components of the overall time series chosen, a description of the variable being tested with time and for a particular point in the bay can be obtained. It should be emphasized that this phase of the analysis is one of straight description

and does not attempt to explain why a particular characteristic varied in a particular manner. Rather, it affords an opportunity to describe the changes in the variable under different time conditions, such as a tidal or annual cycle. The basic assumption involved in the logic of analyzing a complex system in this fashion is that coincidence in time or peak (or minimum) values of a quality characteristic with peak (or minimum) values of an environmental factor implies a cause and effect relationship. Obviously, a cause and effect relationship can be implied only between quality characteristics and environmental factors which have some known logical scientific relationship. For example, it is known or at least suspected that changes in tidal current velocities may alter the MPN pattern due to, among other things, the actual physical transport of water from one location to another.

42. The details of the mathematical methods used to describe the variables chosen are presented in Appendix B. Briefly, the first computations "fit" the observed data by means of multiple correlation techniques to a time series consisting of three sine curves each with different frequencies and amplitude. This particular computation was made at each station-depth point for each quality variable as well as for the tidal height and tidal range variables at selected stations. For this study, an annual frequency of one cycle every 365 days, an average lunar-month cycle of 29.54 days (from new moon to new moon) and a tidal cycle of 12.42 hours (from high water to high water) were chosen for the fitting of the observed data. Previous experiences with this type of analysis indicated that for most quality characteristics, the predominant cycle was an annual one, due chiefly to changes in climatic conditions, notably air and subsequent water temperatures and fresh water inflow.

43. Since the purpose of this study is to assess the effects of proposed barriers, the remaining two cycles which were chosen represent time dimensions during which the major effects of the barriers will be felt. Initially it was planned to include a 14.7 day cycle corresponding to the times of spring tides instead of the 29.5 day cycle finally chosen. However, an inspection of the data which were collected (see Figure 7) together with some preliminary calculations indicated that a predominant cycle of about 27-29 days was present. It was suspected that this cycle may be due to the spring tides at the time of new moon and the predominant 27-29 day cycle in rainfall (see Figure 4). Also, the tidal ranges at the time of full moon during the survey were not as marked as those at the time of the new moon. Further inspection into astronomical conditions during the survey indicated that the three general periods

of relatively intense mixing mentioned previously occurred approximately during the times of the moon's perigee (minimum distance to earth) and also during periods of relatively high rainfall and accompanying winds. Because of these considerations, a cycle of 29.54 days was used in the descriptive phase of the analysis.

44. The choice of a cycle of 12.42 hours corresponding to the average time difference between high water is believed to be fairly self-evident. That the barriers affect tidal heights and currents has been shown by the model studies, the results of which have been discussed in paragraph 13.

45. The results obtained from this sinusoidal analysis afford an opportunity to describe the changes in a water quality variable which occur during different times of the tidal cycle and different times of the lunar month. Due to the fact that the survey covered a period of two out of the twelve months of the year, it is not possible to accurately describe conditions outside the limits of the survey. However, the time of year cycle is present (and in some cases relatively predominant, as will be seen later) and must be taken into account. In order to verify this, sinusoidal analyses were made also for a two cycle analysis (tidal and lunar month cycles). The difference in the amount of variation removed by the addition of the seasonal cycle could then be compared. For some stations, quality data existed for months outside the survey months although for years other than 1959. These data afford an opportunity to estimate the change in quality throughout a year. Suitable statistical parameters indicating the "goodness of fit" of the equation (i. e. the reliability of the equation for describing conditions during the survey) together with other statistical results were used to arrive at the final descriptive equation for each variable.

46. Some of the environmental factors which may affect the water quality do not necessarily vary according to the three-component sinusoidal analysis discussed above. Accordingly, a different approach must be taken. The analysis of environmental factors made in this report makes use of mathematical techniques known as autocovariance analysis and subsequent power spectrum analysis. Some of the details of these analyses are presented in Appendix B. Due to the need for relatively long-term data at equally spaced time intervals, it was not possible to accurately compute power spectra from the presently available data. However, some crude estimates were made in an attempt to explain further

the nature and causes of variations in water quality. These estimates are discussed in a general fashion under the analyses of the dissolved oxygen and MPN data.

47. With the results of the above analyses, the causative relationships between environmental factors and water quality variables can be estimated. In some cases, there are causative relationships between variables themselves, as for example, between temperature and dissolved oxygen and between temperature and the MPN. These relationships do not indicate quantitatively the effect of one variable on another, but rather indicate the fact that variable x affects variable y to some degree, which is as yet unknown.

48. The last phase of the analysis, and the most difficult, attempts to separate the quantitative effects between selected variables. This is done by assuming that some of the results obtained from the above analyses constitute a linear system. (Detailed discussion of this analysis is presented in Appendix B and the application therewith in Section IV.) It should be mentioned here that due to the objectives of this report, the determination of quantitative relationships has been made only for those major phenomena which will be affected by the proposed barriers. Hence, determinations were made between water quality and those tidal factors affected by the barriers. The variations in a quality variable, which remain after the variations due to tidal phenomena have been accounted for, are assumed to represent effects due to environmental factors which will not be changed by the construction of the barriers.

49. Results of analyses of specific conductance (chloride) data The results of the analyses of the specific conductance data are presented in qualitative form in Table 6 with correlation coefficients given in Table B-2 in Appendix B. The sinusoidal analyses were made on the specific conductance data and the final results converted to o/oo chloride ion. For the surface data, Table 6 indicates that in general the seasonal effect is the dominant one, followed closely by the lunar month effect and the tidal cycle effect. As indicated in Appendix B, the use of these three cycles accounted for an average removal of about 50% (multiple correlation coefficient of about 0.72) of the total variation. Total variation is defined as the sum of the squares of the individual deviations from the survey mean. It is assumed then, that the remaining

50% of the variation is due to causes other than the phenomena implied by the use of the three sinusoidal cycles. The amount removed from the total variation actually ranged from a low of 16% (correlation coefficient of 0.4) to a high of 88% (correlation coefficient of 0.94). The statistical tests applied to the results of the analysis indicate that they are significant at the 10% level in all cases except three. For the cases in which the analysis proved non-significant, it is assumed that at these stations the variations during the three chosen cycles are negligible. This is indicated in Table 6 where all three cycles show no discernible effect. It can be said therefore that the surface chloride concentration is measurably affected by the time of year, lunar month and tidal cycle with the greatest effect resulting from the time of year. This may be expected since the variation in fresh water flow and meteorological conditions can be quite large, thereby affecting surface chloride concentrations to a considerable extent.

50. The average amplitude at the surface (maximum deviation from the survey average) during a tidal cycle was about 0.6 o/oo chlorides. At most stations, maximum surface chloride concentrations occurred at about high water ±1-2 hours. The average amplitude of surface chloride concentrations during a lunar cycle was about 1.3 o/oo and maximum concentrations at most stations occurred at about 3-5 days after the time of the new moon. Table B-3 in Appendix B presents computed values at various stages of the tide and at various times of the lunar month with both cycles varying about the survey mean.

51. For the bottom chloride concentrations, it can be seen from Table 6, that the situation is quite different. Here the effect of the time of the lunar month appears to be the most dominant followed by the tidal cycle effect. In general, the seasonal effect does not appear to influence the bottom chloride concentration. This is probably a result of the degree of stratification prevalent in the study area whereby the surface layers are affected by meteorological changes more than the bottom. Only during times of increased vertical mixing does the bottom chloride concentration change significantly. In general, the amount of variation removed by analyzing the bottom chloride concentration was somewhat less than that obtained from analyzing the surface concentrations. The average percentage removal of the total bottom variation was about 33% ($R = 0.57$). It should be remembered, however, that the actual magnitude of the bottom chloride variation is considerably less than that of the surface chloride variation. In other words, the average deviation

TABLE 6

RELATIVE EFFECTS OF TIME PERIODS ON WATER QUALITY VARIABLES

	Chlorides						Temperature					
Sta.	Time of Year		Time of Lunar Month		Time of Tidal Cycle		Time of Year		Time of Lunar Month		Time of Tidal Cycle	
No.	Sur.	Bot.	Sur.	Bot.	Sur.	Bot.	Sur.	Bot.	Sur.	Bot.	Sur.	Bot.
1	4	3	4	1	4	2	1	1	3	3	2	3
2	1	4	2	4	3	4	1	1	4	2	3	4
3	1	3	2	1	3	3	1	1	4	2	3	4
4	1	4	2	1	2	4	1	1	3	2	2	3
5	1	-	2	-	4	-	1	-	3	-	3	-
6	4	3	2	1	2	4	1	1	3	2	2	4
7	1	-	2	-	2	-	1	-	4	-	3	-
8	1	3	2	3	3	1	1	1	3	2	3	2
9	4	1	4	2	4	3	1	1	3	4	2	2
10	1	4	2	3	3	3	1	1	4	4	3	3
11	1	4	2	4	3	2	1	1	2	4	2	2
12	1	2	2	3	3	4	1	1	2	4	2	2
13	1	4	3	2	4	3	1	1	4	3	3	2
14	1	4	3	1	2	3	1	1	4	4	3	3
15	4	4	3	1	1	2	1	1	2	3	2	4
16	4	4	3	1	1	3	1	3	2	2	2	3
17	4	4	3	2	1	3	1	1	2	4	3	4
18	3	4	2	4	2	3	1	1	4	3	3	2
19	1	4	2	4	3	4	1	1	3	2	2	2
20	1	4	2	4	3	4	1	1	4	3	4	4
21	2	4	1	1	2	4	1	1	4	3	4	3
22	4	1	4	2	4	2	1	1	3	3	4	3
23	1	4	2	2	2	1	1	1	4	3	4	3
24	1	2	2	2	2	1	1	1	4	3	4	3
25	1	2	2	2	2	2	1	1	4	3	4	3
26	1	1	2	2	3	3	1	1	4	3	3	3
27	1	2	2	1	4	3	1	1	4	3	3	3
28	1	2	2	1	3	3	1	1	4	3	3	4
29	1	1	2	2	3	3	1	1	4	3	4	4

1. Major effect
2. Moderate effect
3. Minor effect
4. No discernible effect

TABLE 6 (Continued)

RELATIVE EFFECTS OF TIME PERIODS ON WATER QUALITY VARIABLES

	Dissolved Oxygen						MPN					
Sta.	Time of Year		Time of Lunar Month		Time of Tidal Cycle		Time of Year		Time of Lunar Month		Time of Tidal Cycle	
No.	Sur.	Bot.	Sur.	Bot.	Sur.	Bot.	Sur.	Bot.	Sur.	Bot.	Sur.	Bot.
1	1	1	4	3	4	2	4	4	4	4	4	2
2	3	1	2	3	4	2	3	4	3	4	2	2
3	4	1	2	2	1	4	4	4	4	4	4	4
4	3	1	2	2	1	3	2	4	4	4	1	2
5	4	-	4	-	1	-	3	-	4	-	3	-
6	1	1	2	2	2	3	3	4	4	4	1	2
7	4	-	4	-	1	-	2	-	4	-	1	-
8	4	1	2	2	2	4	2	4	4	4	1	1
9	4	1	4	4	4	3	4	4	4	3	3	1
10	4	1	3	4	1	3	4	3	4	4	2	2
11	4	1	3	4	1	2	4	4	4	3	4	3
12	4	1	2	2	1	2	4	4	4	3	4	2
13	4	1	4	2	4	2	3	3	4	4	3	2
14	3	1	3	3	1	2	4	4	2	4	3	4
15	4	1	3	2	4	2	4	4	4	4	4	4
16	3	1	4	3	4	2	4	4	4	2	4	2
17	3	1	2	2	3	2	4	4	3	4	3	2
18	4	1	3	2	4	2	4	4	4	4	2	3
19	2	1	3	3	1	3	4	4	4	4	4	3
20	4	1	1	2	4	4						
21	4	1	3	2	3	4						
22	2	1	4	4	4	3						
23	1	1	4	4	4	3						
24	3	1	3	4	4	3						
25	3	1	3	3	1	2						
26	1	2	4	3	3	1						
27	3	2	3	3	4	1						
28	3	2	4	2	2	3						
29	2	4	3	2	1	1						

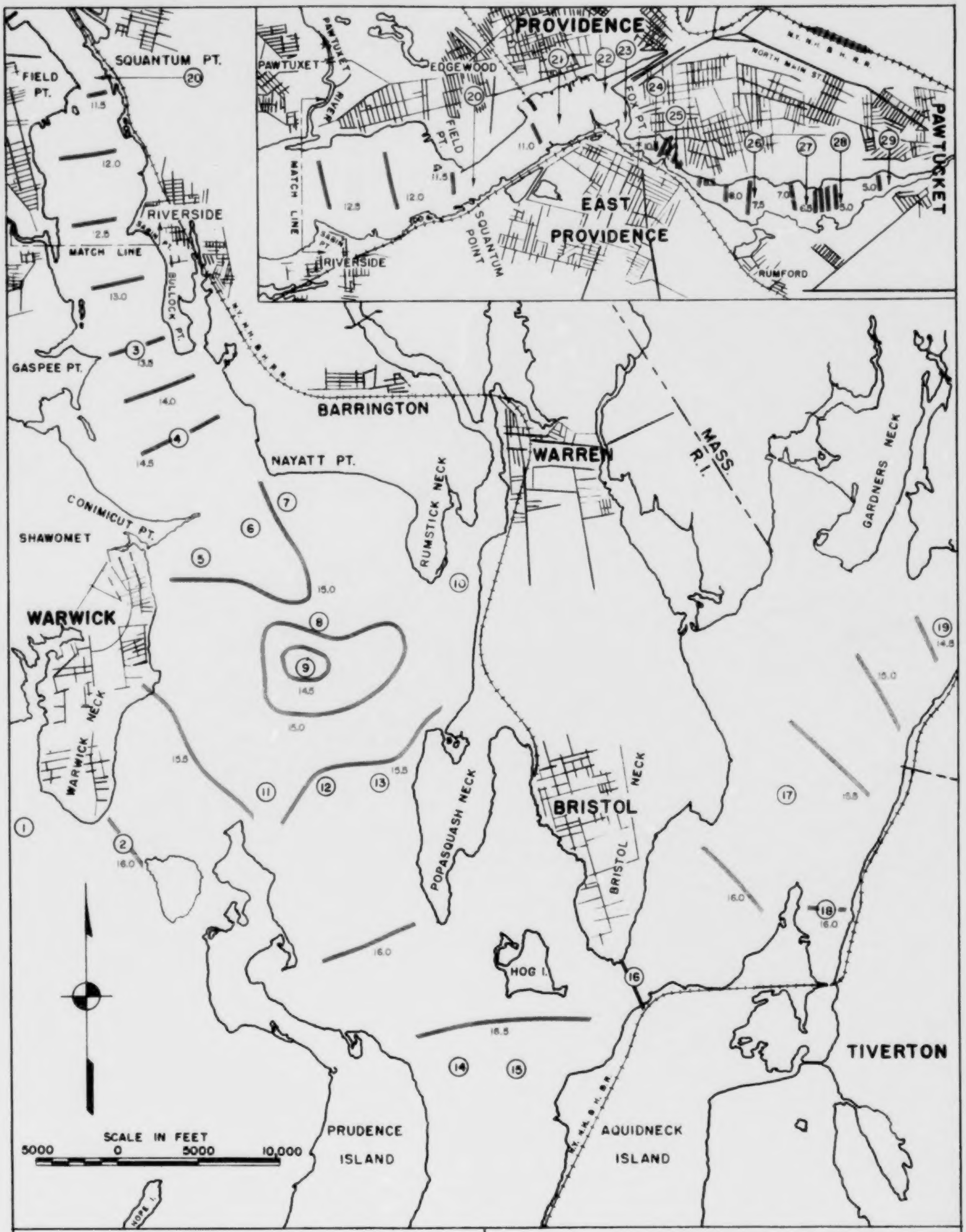
1. Major effect
2. Moderate effect
3. Minor effect
4. No discernible effect

from the mean of the bottom chloride concentration was about 0.5-0.6 o/oo whereas for the top the average deviation was about 1.5-2.0 o/oo. Statistical tests applied to the results of the bottom data indicated that, in most cases, the results were significant at the 10% level and in only three cases were the results interpreted as being non-significant. This essentially means that at some stations the effect of all three cycles is negligible and the variation in chloride concentration at these stations, although relatively small, appears to be due to other causes than those implied by the sinusoidal analyses.

52. An examination of the phase angles (from which the times of maximum concentrations can be obtained) determined by the analysis of the bottom chloride values indicates a less uniform pattern than that obtained from the surface analyses. However, some general observations can be made. It appears that along the route given by station numbers 3-4-6-8-13, maximum bottom chloride concentrations occur at about the time of low water. This indicates the movement of the bottom layer in a direction opposite to that of the surface layer. Further, the maximum excursion length of the bottom layer of Upper Narragansett Bay water into the Providence River is between stations #3 and #20. Station #12-bottom, as indicated in Table 6, evidenced no discernible tidal variation whereas #11 and #13 on both sides of #12 indicated some tidal variation. The tidal phase angle relationships indicate that for station #11 maximum chloride concentrations occur at about the same time for both top and bottom. However, at station #13 the maximum concentration at the surface occurs at high water whereas the maximum bottom concentration occurs almost one-half of a tidal cycle later. This appears to indicate an extremely complex situation in the passage between Prudence Island and Popasquash Neck. The situation is made complex by the occurrence of lateral, vertical and longitudinal current gradients.

53. An analysis of the phase angles for the lunar month indicates the effects of increased current velocities during the time of new moon. Vertical mixing appears to be more intense as evidenced by the reduced vertical gradient during this time. Concurrently, however, the extent of travel of particular isochlors in the longitudinal direction (e. g. into Upper Narragansett Bay from the Providence River) becomes considerably greater. Table B-4 in Appendix B presents computed values at various stages of the tide and various times of the lunar month.

54. Figures 12, 13, 14 and 15 indicate more pictorially the water movement during a tidal cycle. These figures were prepared under mean

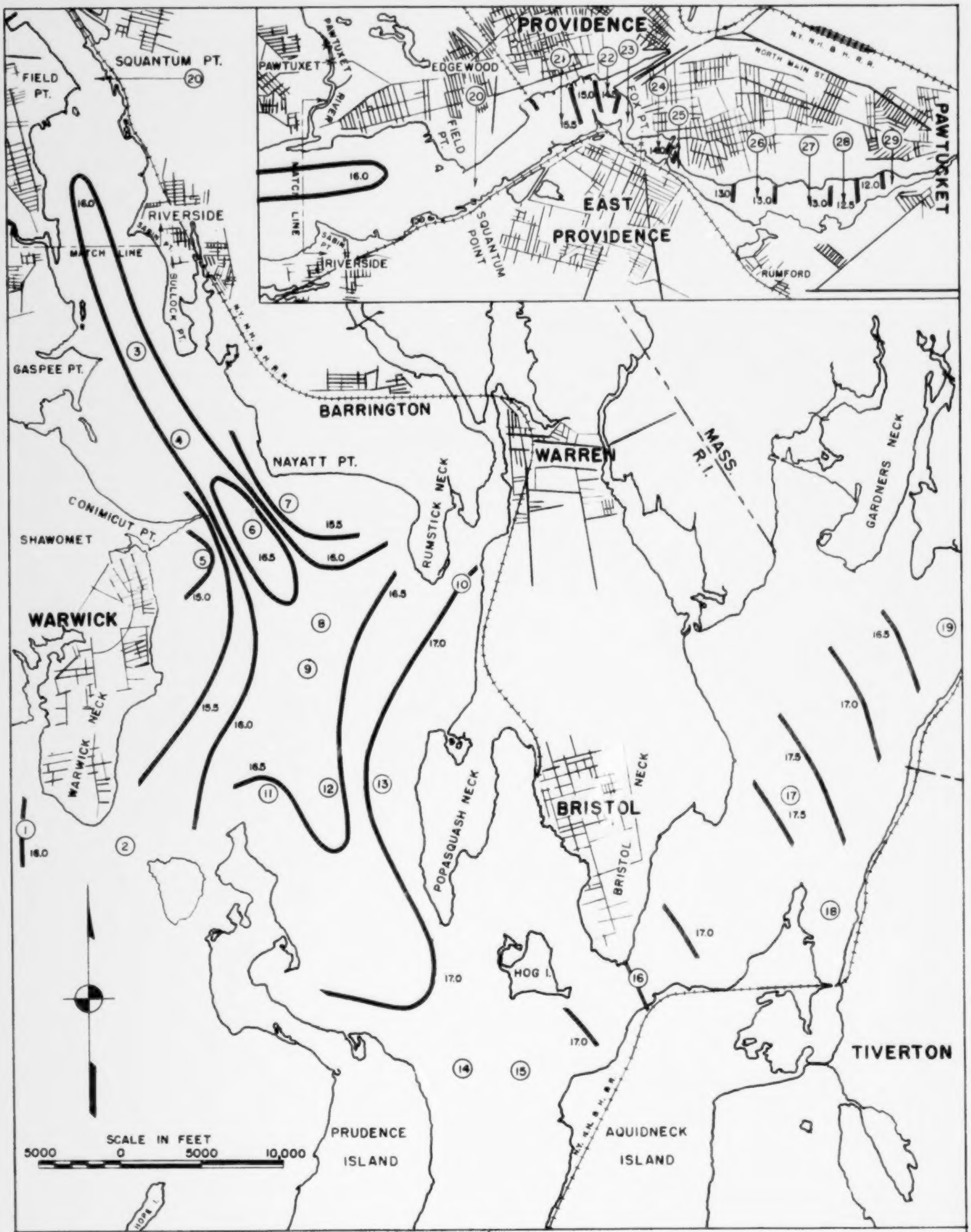

PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
FOX PT.
PAWTUCKET
MATCH LINE
SQUANTUM POINT
EAST PROVIDENCE
RIVERSIDE
RUMFORD
20
21
22
23
24
25
26
27
28
29
12.5
12.0
11.5
11.0
8.0
7.5
7.0
6.5
5.0
5.0
SQUANTUM PT.
FIELD PT.
RIVERSIDE
MATCH LINE
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
SCALE IN FEET
5000 0 5000 10,000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
11.5
12.0
12.5
13.0
13.5
14.0
14.5
15.0
14.5
15.0
15.5
15.5
16.0
16.0
16.5
14.5
15.0
15.5
16.0
16.0

EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

30-a

FIGURE 12
ISOCHLORS (‰)
AT HIGH WATER + 0.0 HOURS
SURFACE


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
PAWTUCKET
MATCH LINE
SABIN PT.
RIVERSIDE
SQUANTUM POINT
EAST PROVIDENCE
RUMFORD
15.0
15.5
14.0
13.0
13.0
13.0
12.5
12.0
16.0
SQUANTUM PT.
FIELD PT.
GASPEE PT.
BULLOCK PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
PRUDENCE ISLAND
AQUIDNECK ISLAND
TIVERTON
HOPE I.
SCALE IN FEET
5000
0
5000
10,000
16.5
16.0
15.0
15.5
17.0
17.5
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
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EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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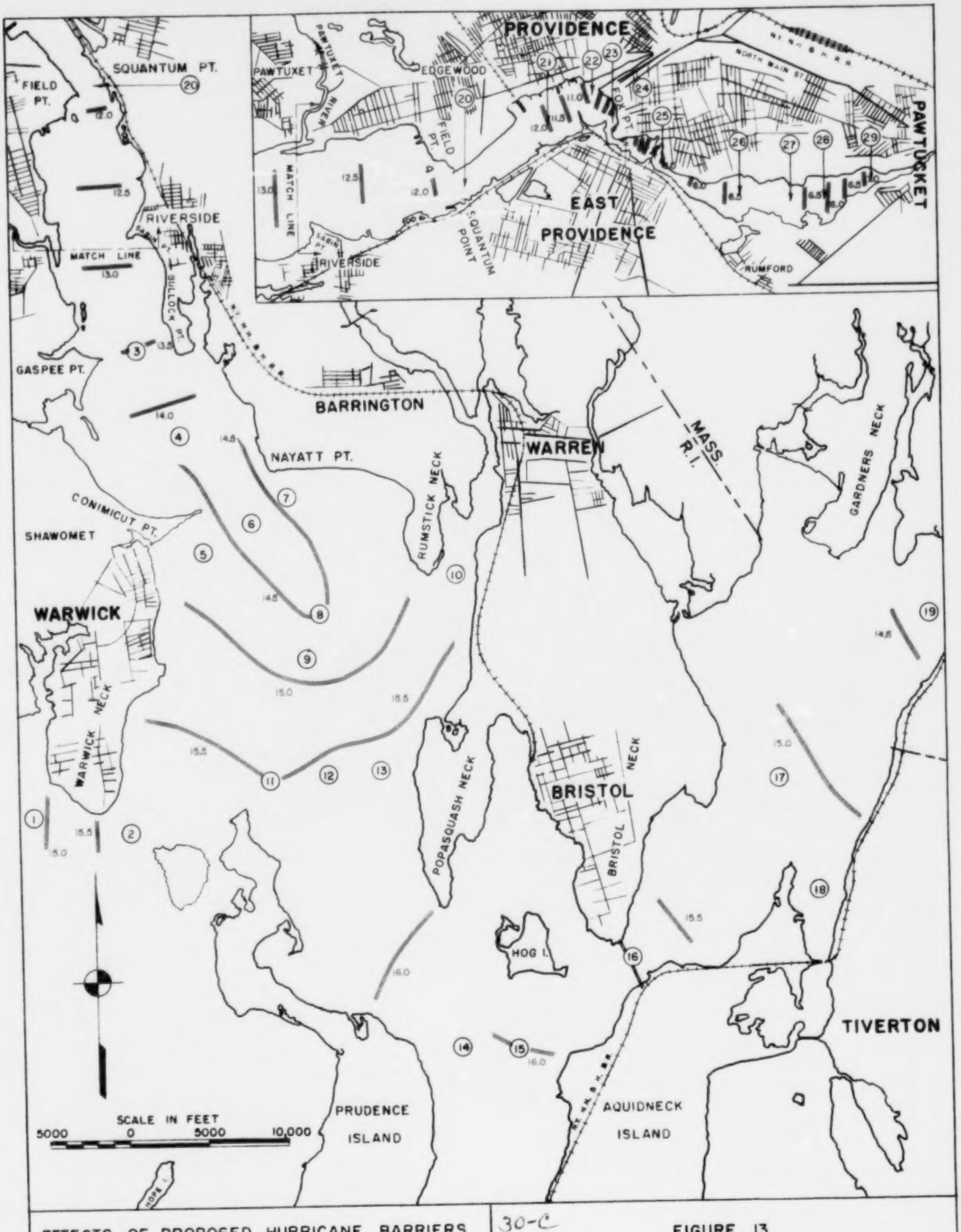
EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

30-6

FIGURE 12
ISOCHLORS (‰)
AT HIGH WATER + 0.0 HOURS
BOTTOM


PROVIDENCE
PAWTUCKET
EAST PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
SQUANTUM POINT
SQUANTUM PT.
FOX PT.
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
RUMFORD
RIVERSIDE
SABIN PT.
MATCH LINE
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
SCALE IN FEET
5000
0
5000
10,000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
11.0
11.5
12.0
12.5
13.0
13.5
14.0
14.5
14.8
15.0
15.5
16.0
6.0
6.5
8.0

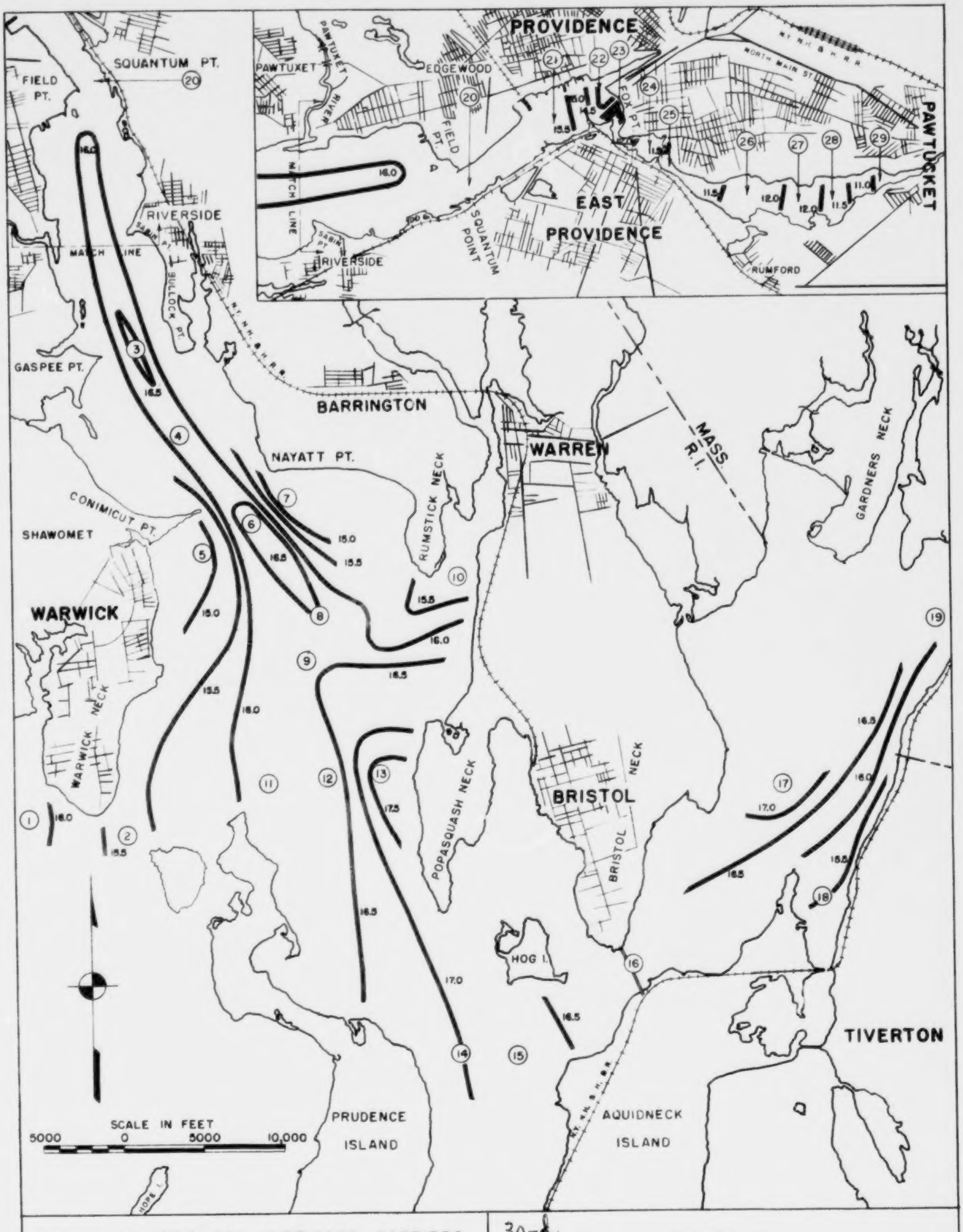
EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

U.S. DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

30-C

FIGURE 13
ISOCHLORS (‰)
AT HIGH WATER + 3.1 HOURS

SURFACE


PROVIDENCE
PAWTUXET
EDGEWOOD
PAWTUXET RIVER
FIELD PT.
SQUANTUM POINT
EAST PROVIDENCE
RIVERSIDE
SABIN PT.
MATCH LINE
FOX PT.
NORTH MAIN ST.
N.Y. N.H. & H.R.R.
RUMFORD
PAWTUCKET
21
22
23
24
25
26
27
28
29
20
16.0
15.5
15.0
11.5
12.0
11.0
SQUANTUM PT.
FIELD PT.
GASPEE PT.
BULLOCK PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
HOPE I.
PRUDENCE ISLAND
AQUIDNECK ISLAND
TIVERTON
SCALE IN FEET
5000
0
5000
10,000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
16.0
16.5
15.5
15.0
16.5
17.0
17.5

EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

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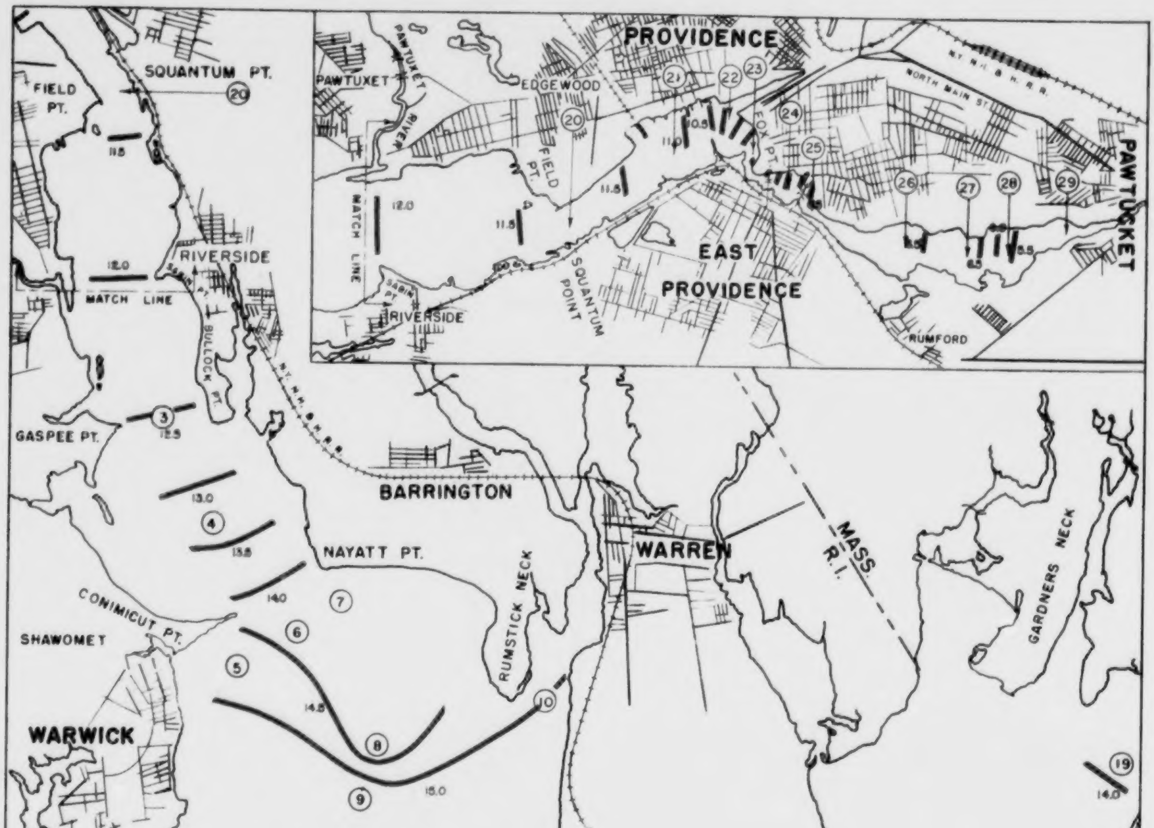
PUBLIC HEALTH SERVICE

30-2

FIGURE 13
ISOCHLORS (‰)
AT HIGH WATER + 3.1 HOURS

BOTTOM


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
PAWTUCKET
MATCH LINE
SQUANTUM POINT
EAST PROVIDENCE
RIVERSIDE
SABIN PT.
RUMFORD
21
22
23
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25
26
27
28
29
20
12.0
11.5
11.0
10.5
6.5
SQUANTUM PT.
FIELD PT.
RIVERSIDE
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
N.Y. N.H. & H. R.R.
SCALE IN FEET
5000
0
5000
10,000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
11.5
12.0
12.5
13.0
13.5
14.0
14.5
15.0
15.5

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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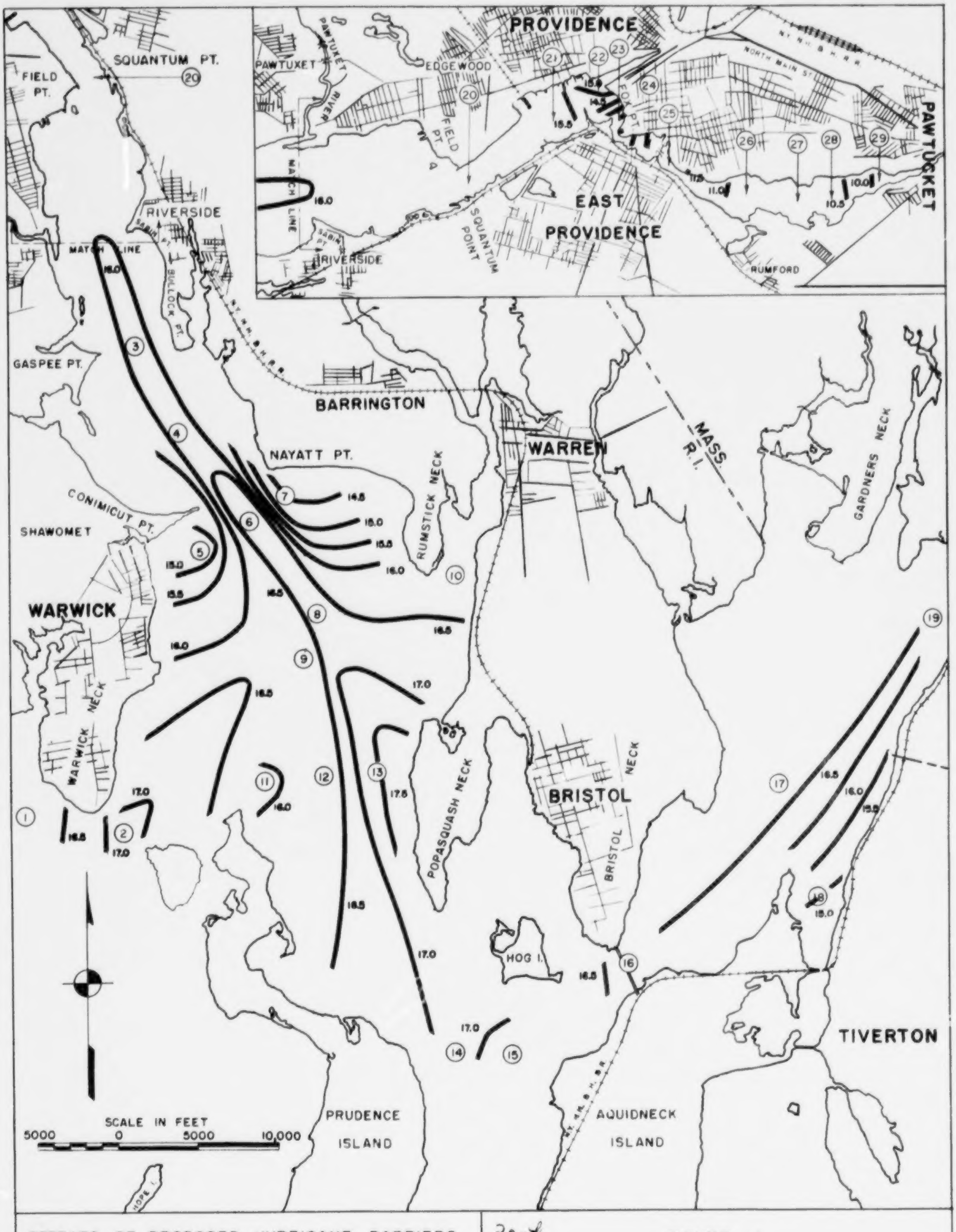
30-2

FIGURE 14
ISOCHLORS (‰)
AT HIGH WATER + 6.2 HOURS

SURFACE


PROVIDENCE
PAWTUXET
EDGEWOOD
PAWTUXET RIVER
NORTH MAIN ST.
PAWTUCKET
FOX PT.
FIELD PT.
MATCH LINE
EAST PROVIDENCE
SQUANTUM POINT
SABIN PT.
RIVERSIDE
RUMFORD
SQUANTUM PT.
FIELD PT.
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
SCALE IN FEET
5000
0
5000
10,000
18.0
14.5
15.0
15.5
16.0
16.5
17.0
17.5
11.5
11.0
10.5
10.0
18.5

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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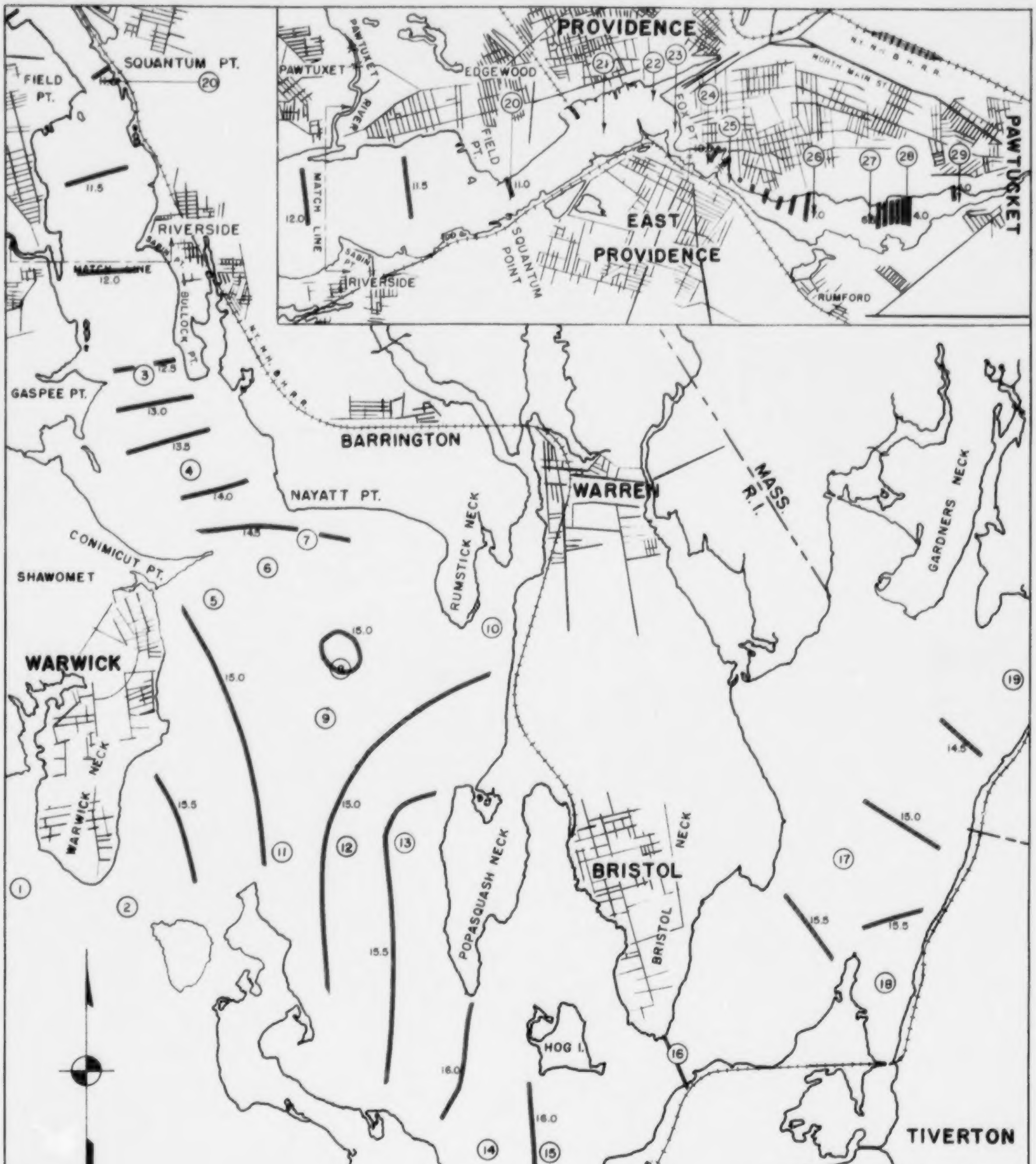
PUBLIC HEALTH SERVICE

30-f

FIGURE 14
ISOCHLORS (‰)
AT HIGH WATER + 6.2 HOURS

BOTTOM


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
MATCH LINE
SABIN PT.
RIVERSIDE
SQUANTUM POINT
EAST PROVIDENCE
FOX PT.
RUMFORD
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
PAWTUCKET
FIELD PT.
SQUANTUM PT.
RIVERSIDE
MATCH LINE
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
SCALE IN FEET
5000
0
5000
10,000
11.0
11.5
12.0
12.5
13.0
13.5
14.0
14.5
15.0
15.5
16.0
4.0
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29

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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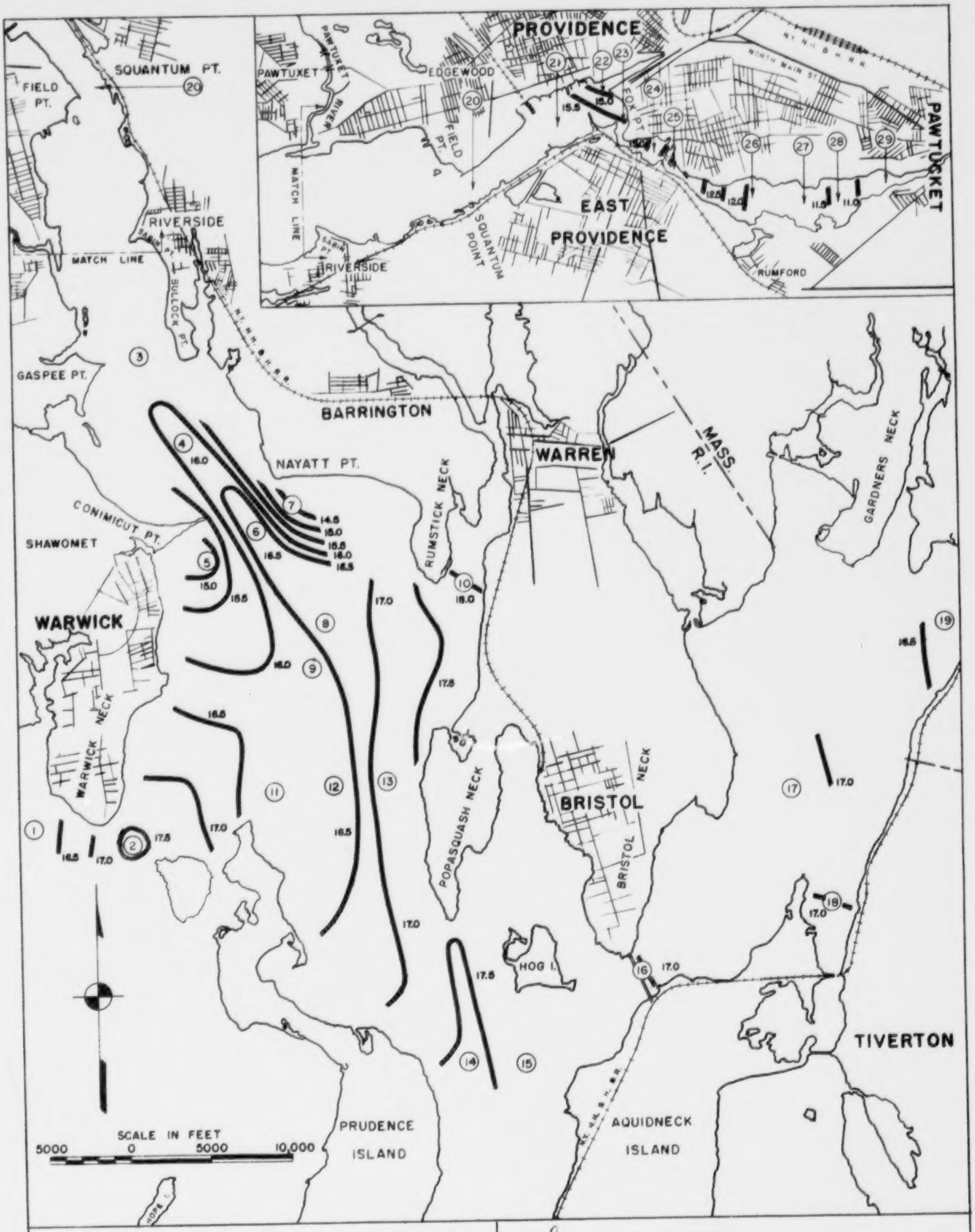
PUBLIC HEALTH SERVICE

30-9

FIGURE 15
ISOCHLORS (‰)
AT HIGH WATER + 9.3 HOURS

SURFACE


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
PAWTUCKET
EAST PROVIDENCE
SQUANTUM POINT
RIVERSIDE
SABIN PT.
RUMFORD
MATCH LINE
15.5
15.0
12.5
12.0
11.5
11.0
21
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29
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FIELD PT.
SQUANTUM PT.
RIVERSIDE
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
SCALE IN FEET
5000 0 5000 10,000
1
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10
11
12
13
14
15
16
17
18
19
14.5
15.0
15.5
16.0
16.5
17.0
17.5

EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

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FIGURE 15
ISOCHLORS (‰)
AT HIGH WATER + 9.3 HOURS

BOTTOM

lunar month conditions; hence, the position of any given isochlor changes during various times of the lunar month. The values used to prepare these figures are those given in Tables B-3,4 for a tidal cycle. For example, in Figure 12, surface, the 15.0 isochlor which predominates the Upper Bay area extends into the Providence River between stations #3 and #4 during the time of new moon. Likewise, in Figure 15, surface, the 14.0 isochlor which lies between stations #4 and #6 extends into the Upper Bay and reaches as far as station #9 during the last quarter of the moon, thereby reflecting the decreased current velocities.

55. Close examination of Figures 12-15 indicates the general tendency of bottom waters to flood while surface waters are ebbing. This appears to be true for Upper Narragansett Bay and the Providence River as well as for Mount Hope Bay. For HW + 0.0 (Figure 12), a general pseudo-steady state pattern seems to exist. At HW + 3.1 hours (Figure 13), it can be seen that the surface is ebbing (note 14.5 o/oo isochlor) while the bottom, at least in the Upper Bay and Mount Hope Bay area, appears to be flooding. However, there is an ebbing flow along the bottom proceeding out of the Warren River which tends to deflect the predominant flooding flow of the East Passage. This tends to impart a rotational effect to the flow in Upper Narragansett Bay. At HW + 6.2 hours (Figure 14), a general flooding for both the surface and bottom can be observed from the West Passage into the Upper Bay which appears to persist in the HW + 9.3 hour sketch. For all plots the general lack of any longitudinal gradient along the bottom from stations #3 to #22 can be noted. These plots indicate the complex nature of water movement throughout the Bay. It should be remembered that Figures 12-15 are for an average tidal cycle; hence, considerable variations can occur in the location of any of the isochlors depending on the different meteorological and astronomical conditions which may occur.

56. Summary of conclusions The results of the analyses of the chloride data indicate the following:

a) Chloride concentrations in the upper strata are affected primarily by the time of year, thereby implying the pronounced effects of meteorological conditions, although in most cases tidal influences are present. Average amplitude during a tidal cycle is about 0.6 o/oo chlorides.

b) Chloride concentrations in the bottom layers, although relatively more constant than in the upper layers, are affected primarily by tidal influences and not to any great extent by seasonal factors. Average amplitude during a tidal cycle is also about 0.6 o/oo chlorides.

c) The study area appears to exhibit a net seaward flow on the surface and a net landward flow along the bottom.

d) In the upper end of East Passage (stations #11, 12, and 13 to #14 and #15) lateral, vertical and longitudinal current gradients exist.

e) For a period of about 3 hours (HW + 6.2 to HW + 9.3 hours) there is a general flooding for both the surface and bottom from the West Passage into Upper Narragansett Bay although vertical stratification still exists.

57. Results of analyses of temperature data In referring to Table 6, it can be seen that for both surface and bottom temperatures the greatest effect is the seasonal one although, in some cases, tidal influences are present. That the seasonal influence was predominant is further evidenced by comparing the results of the sinusoidal analyses both with and without the seasonal cycle. When the seasonal cycle was included a three to four fold increase in the amount of variation removed was obtained, thereby indicating the dominant, almost overriding, effect of the time of year on water temperatures. The results of the three cycle analysis indicate that about 78% average removal was obtained (see Table B-2, Appendix B). This means that in general there is a relatively small amount of variation in water temperature which has not been accounted for, but is not due to the three time cycles used.

58. Although some tidal influences are present at any given station, the maximum variation during a tidal cycle is only about 0.5-1.0°C. for bottom temperatures. For surface temperatures, the amplitude is somewhat higher approaching about 1.0-1.5°C. These amplitudes represent a relatively small change in water temperature in relation to the range which might occur over a period of a year. An indication of this latter variation was obtained by using some data outside the limits of the survey. These data have been mentioned previously in paragraph 18. The analyses of temperature variations, which included this data, accounted for an average removal of better than 90% (multiple correlation coefficient of 0.96). The average amplitude across the year was about 10.5°C. or a total range throughout the year of 21°C. Hence, the variation in water temperature during a tidal cycle is seen to be quite small although it still appears to be present.

59. Examination of the phase angle relationships determined from analyzing the surface temperatures indicates that in general higher

temperatures occur between HW + 6.2 hours and HW + 9.3 hours. For the bottom temperature analyses the phase angle relationships tend to indicate lower water temperatures between HW + 6.2 hours and HW + 9.3 hours. It appears then, that as the surface is ebbing, producing higher temperatures at low water, the bottom layers are flooding as indicated by lower temperature water intruding into the study area. Of course, this is not true for all locations in the study area but as a generality it is sufficiently accurate.

60. A better picture of the tidal variations in temperature can be obtained by examining Figures 16, 17, 18 and 19. These figures show that although the variation in temperature at any given station is generally small, there are marked lateral, longitudinal and vertical temperature gradients. Note for example in Figure 16, surface and bottom, the longitudinal gradients in Mount Hope Bay and the entrance to East Passage where differences of about 3°C. for both surface and bottom are indicated. Also, in the same figure the greatest degree of vertical stratification, a difference of 4°C. from surface to bottom, is seen to occur at station #8. This difference can be noted also in the remaining figures where the magnitude of the vertical stratification appears to be maintained throughout a tidal cycle. As with the chloride variation (see Figures 14 and 15) a general flooding at the surface and bottom from station #2 into the Upper Bay can be seen in Figures 18 and 19. Also, the same can be noted regarding the flooding from station #10 into the Upper Bay area. Apparently, these two occurrences tend to "pinch" bottom flows flooding into the channel, thereby deflecting these flows and causing an ebbing bottom flow along the eastern end of Prudence Island. It is interesting to note also the lack of any pronounced longitudinal temperature gradient in the Providence and Seekonk Rivers, although the temperature of the Providence at Fox Point tends to be higher reflecting the heated industrial discharges above Fox Point.

61. Summary of conclusions From the above discussion the following conclusions can be summarized:

a) Both surface and bottom water temperatures in the study area are affected primarily by the time of year implying the pronounced effects of meteorological conditions, notably seasonal changes in air temperatures.

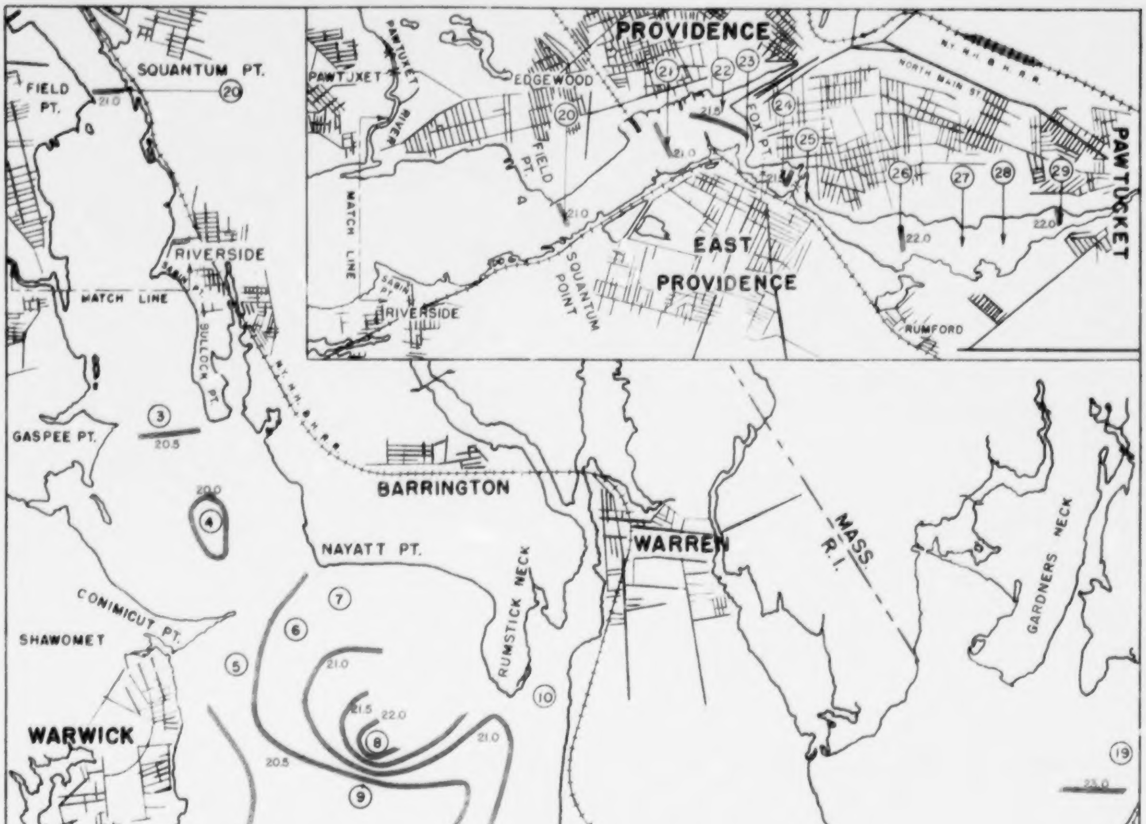
b) Small tidal cycle temperature variations are present ranging from about 0.5-1.5°C.

c) Analysis of the temperature data further confirms the general presence of a two-layered system where the bottom layers are flooding while the surface layers are ebbing.

d) The complex situation in the upper end of East Passage consisting of lateral, vertical and longitudinal gradients may be due to the flooding from stations #2 and #10 into Upper Narragansett Bay which deflects the channel flow back on itself producing a lateral gradient and longitudinal gradient as well as the vertical gradient.

62. Results of analyses of dissolved oxygen data Table 6 indicates the relative contribution of the three time cycles to the variation in dissolved oxygen. For the surface, the apparent paradoxical situation exists whereby the dissolved oxygen in general is not affected by the time of year. This is probably due to the wide range of values of dissolved oxygen observed during the survey, which have been previously noted (see Figure 7). These ranges apparently covered almost all values which would be expected during a year thereby resulting in a decreased seasonal effect. It should be noted that this is not true for all stations in the survey area. The results of analyses made on the survey data plus data collected in other years outside the limits of the survey indicate that a seasonal influence is present but not to the degree as was present in the temperature analyses. Hence, for the surface dissolved concentration high and low values may be expected at any time during the year. Here, "high and low" refers to the maximum and minimum dissolved oxygen values at a given station. For example, at station #3, "high" may be 11.0 to 12.0 ppm and "low" may be 2.0 to 3.0 ppm, whereas at station #15, "high" may be 10.0 to 11.0 ppm and "low" may be 6.0 to 7.0 ppm. The fact that high and low surface dissolved oxygen concentrations may be expected to occur at any time during a year indicates the effects of shorter time periods, or time periods resulting from causes which are aperiodic. These latter causes are probably meteorological ones which do not occur, in general, with any degree of regularity. This is in contrast to the surface chloride concentrations which showed a marked seasonal variation which is also attributed to meteorological causes. These causes, however, appear to occur with a certain degree of regularity. Also for the surface chloride concentrations extremely large ranges were not observed during the survey, at least not in the relative degree of magnitude as was observed for the dissolved oxygen.

63. Inspection of Table 6 for the bottom dissolved oxygen concentrations indicates just the opposite of the surface dissolved oxygen and also the opposite of the bottom chloride variations. In this case, it is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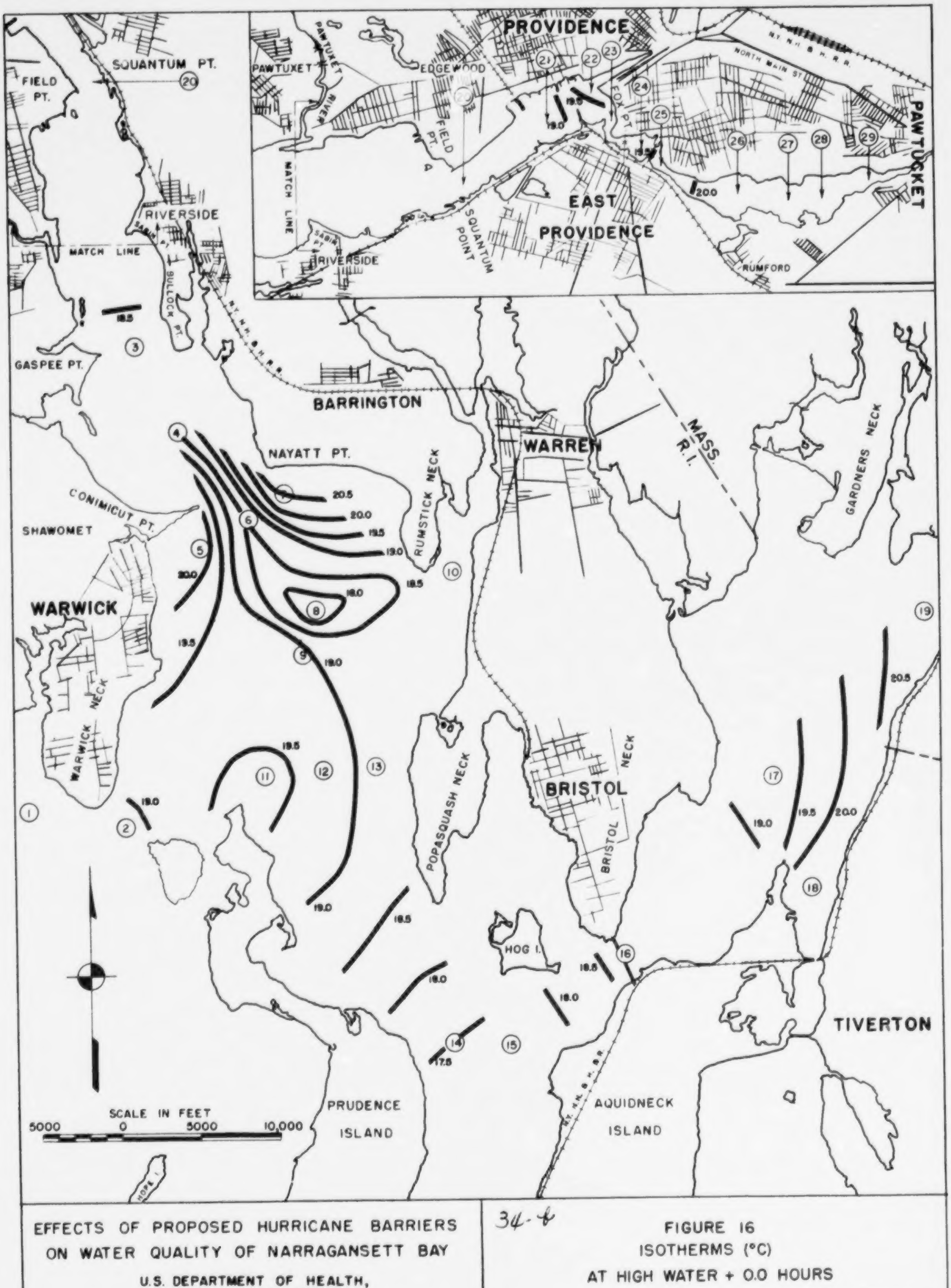
EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

FIGURE 16
ISOTHERMS (°C)
AT HIGH WATER + 0.0 HOURS
SURFACE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BULLOCK PT.
GASPEE PT.
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MASS.
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NAYATT PT.
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EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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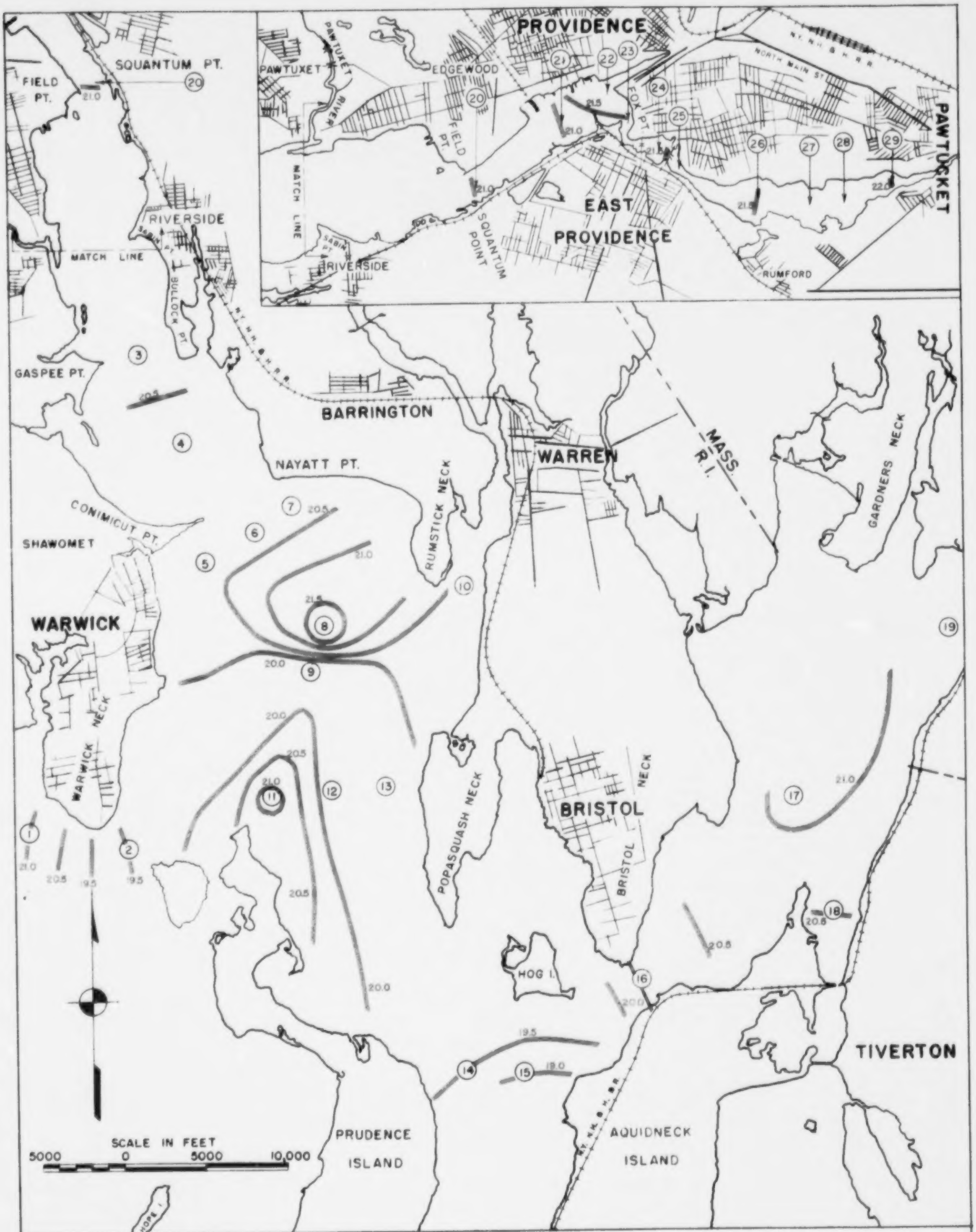
34-8

FIGURE 16
ISOTHERMS (°C)
AT HIGH WATER + 0.0 HOURS

BOTTOM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EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

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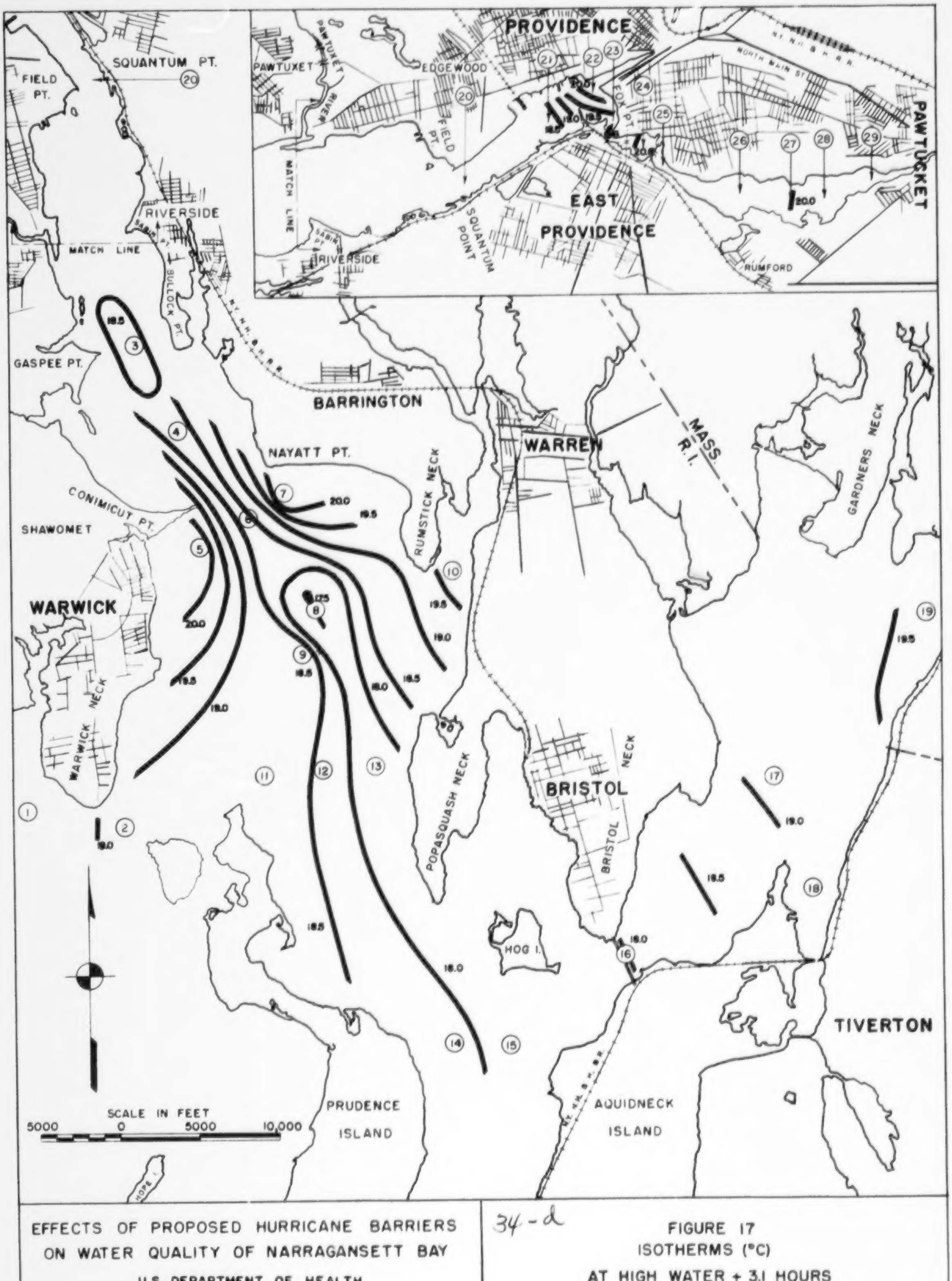
34-C

FIGURE 17
ISOTHERMS (°C)
AT HIGH WATER + 3.1 HOURS

SURFACE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EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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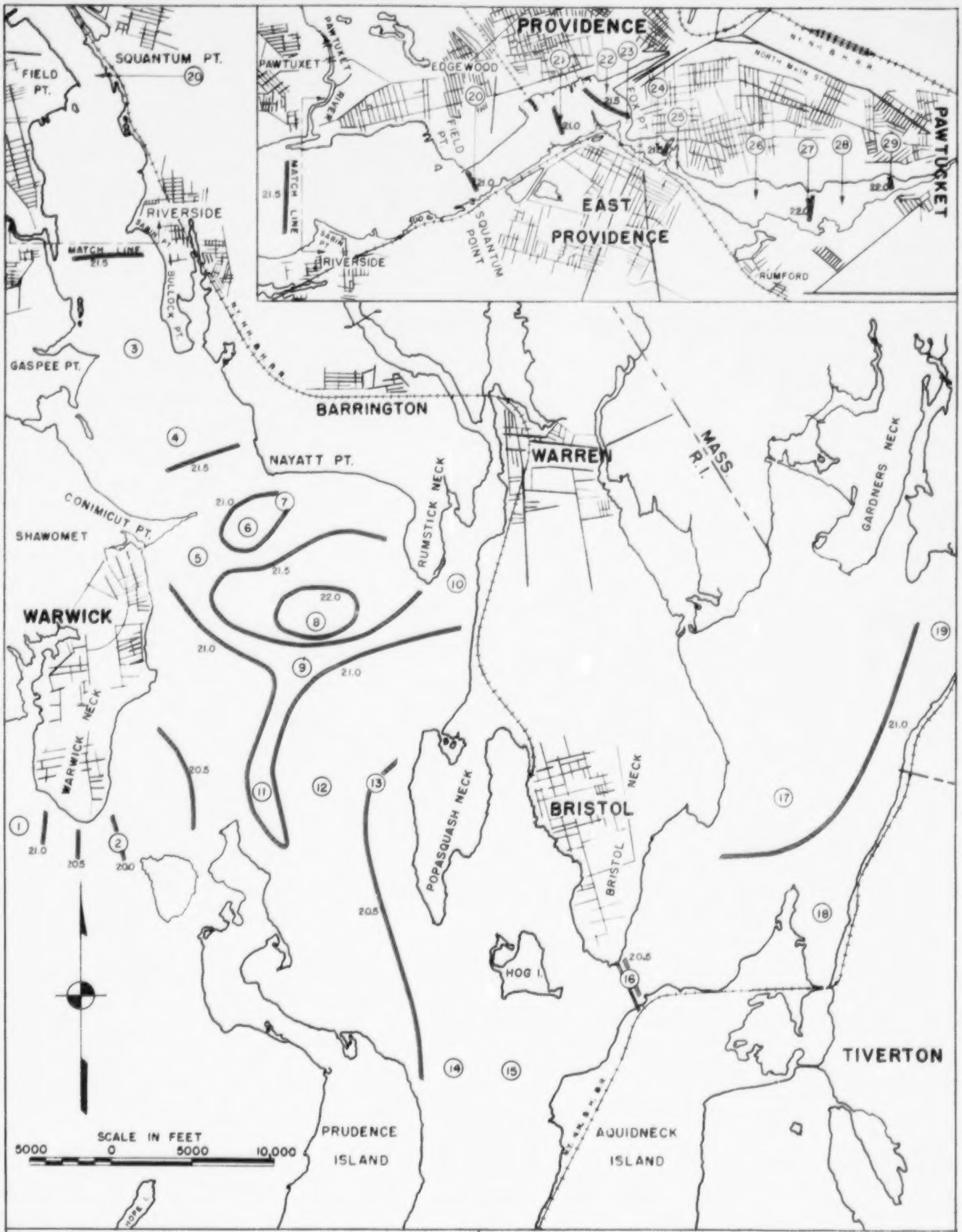
EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

34-d

FIGURE 17
ISOTHERMS (°C)
AT HIGH WATER + 3.1 HOURS

BOTTOM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EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

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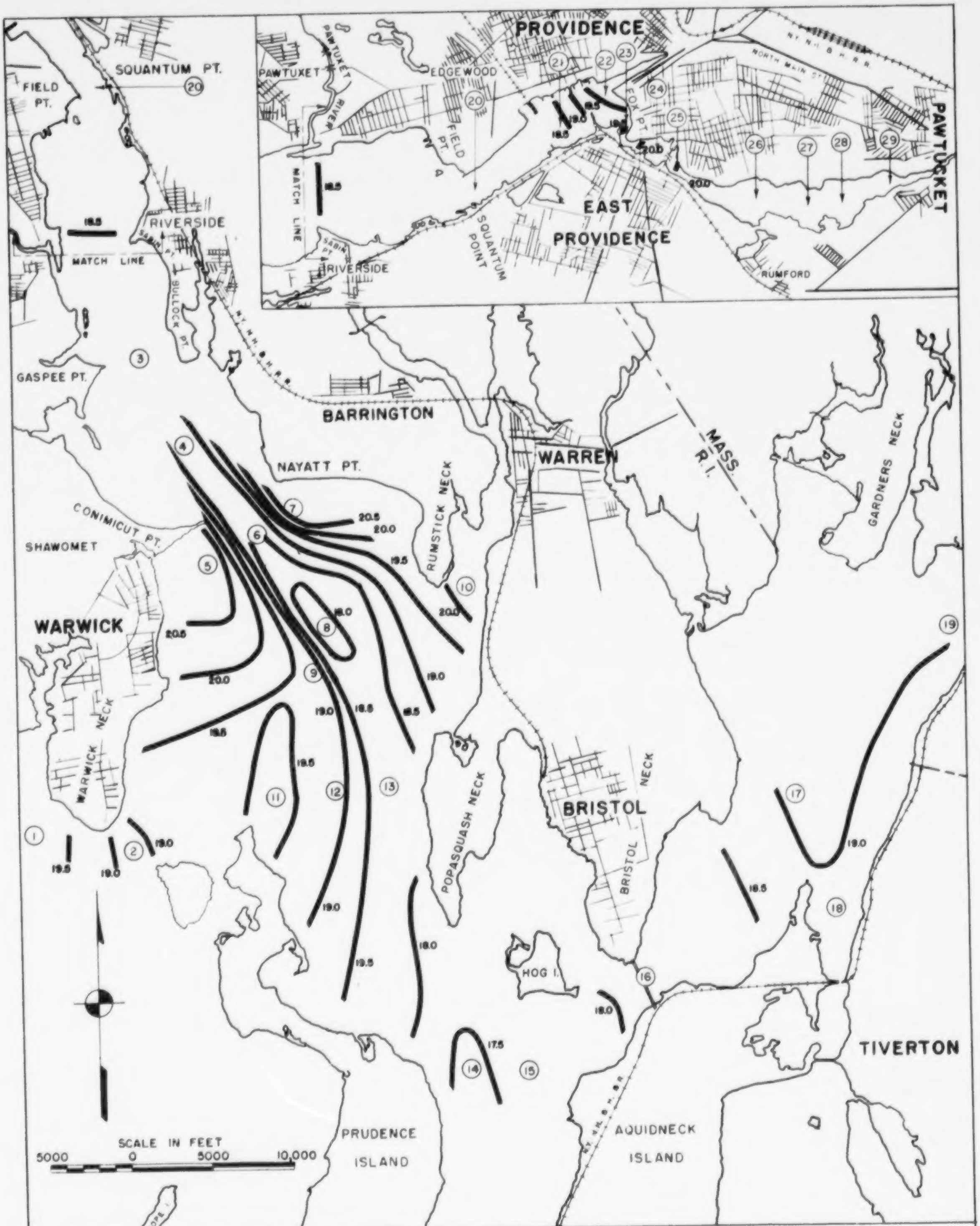
34-2

FIGURE 18
ISOTHERMS (°C)
AT HIGH WATER + 6.2 HOURS
SURFACE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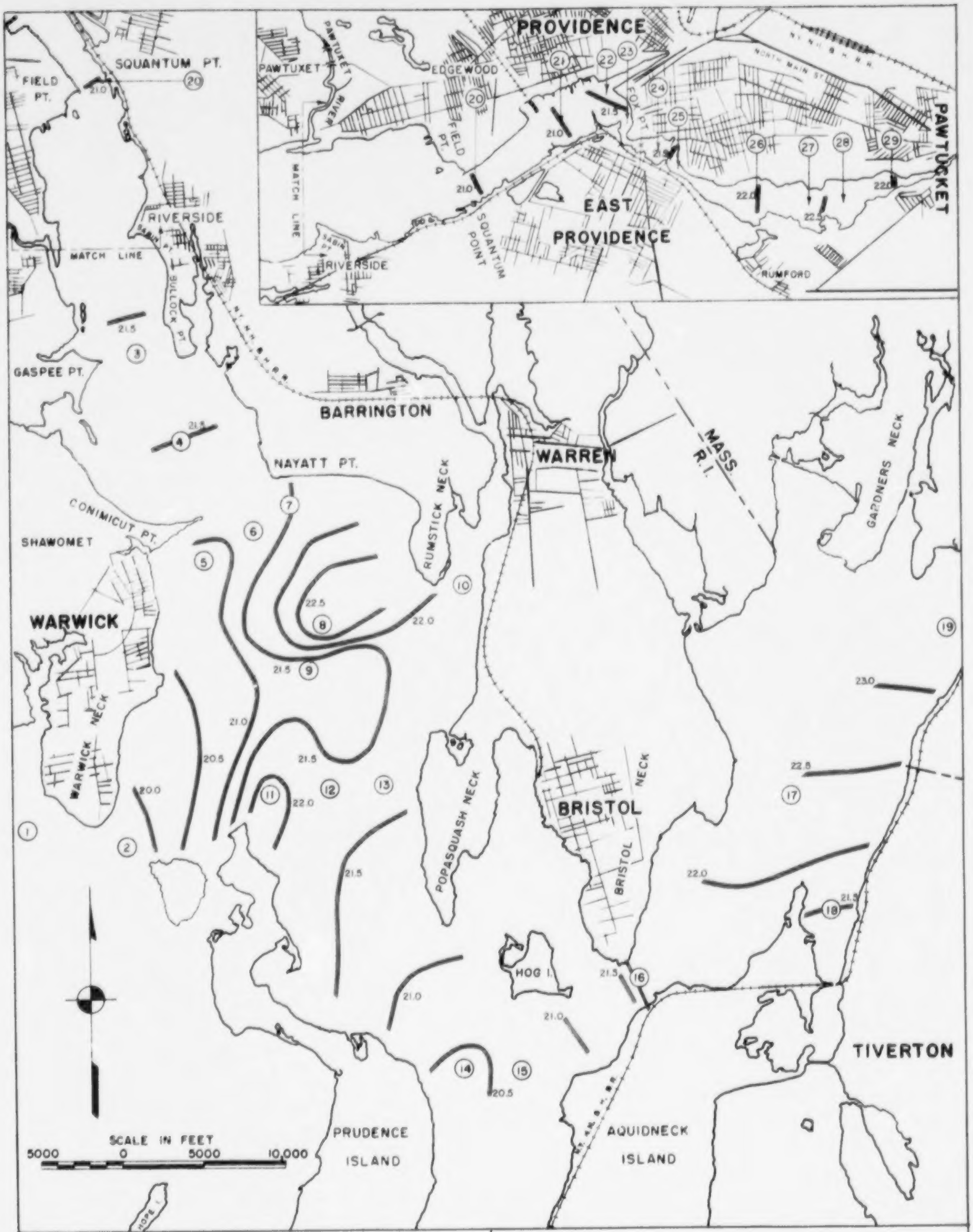
EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

34-7

FIGURE 18
ISOTHERMS (°C)
AT HIGH WATER + 6.2 HOURS

BOTTOM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EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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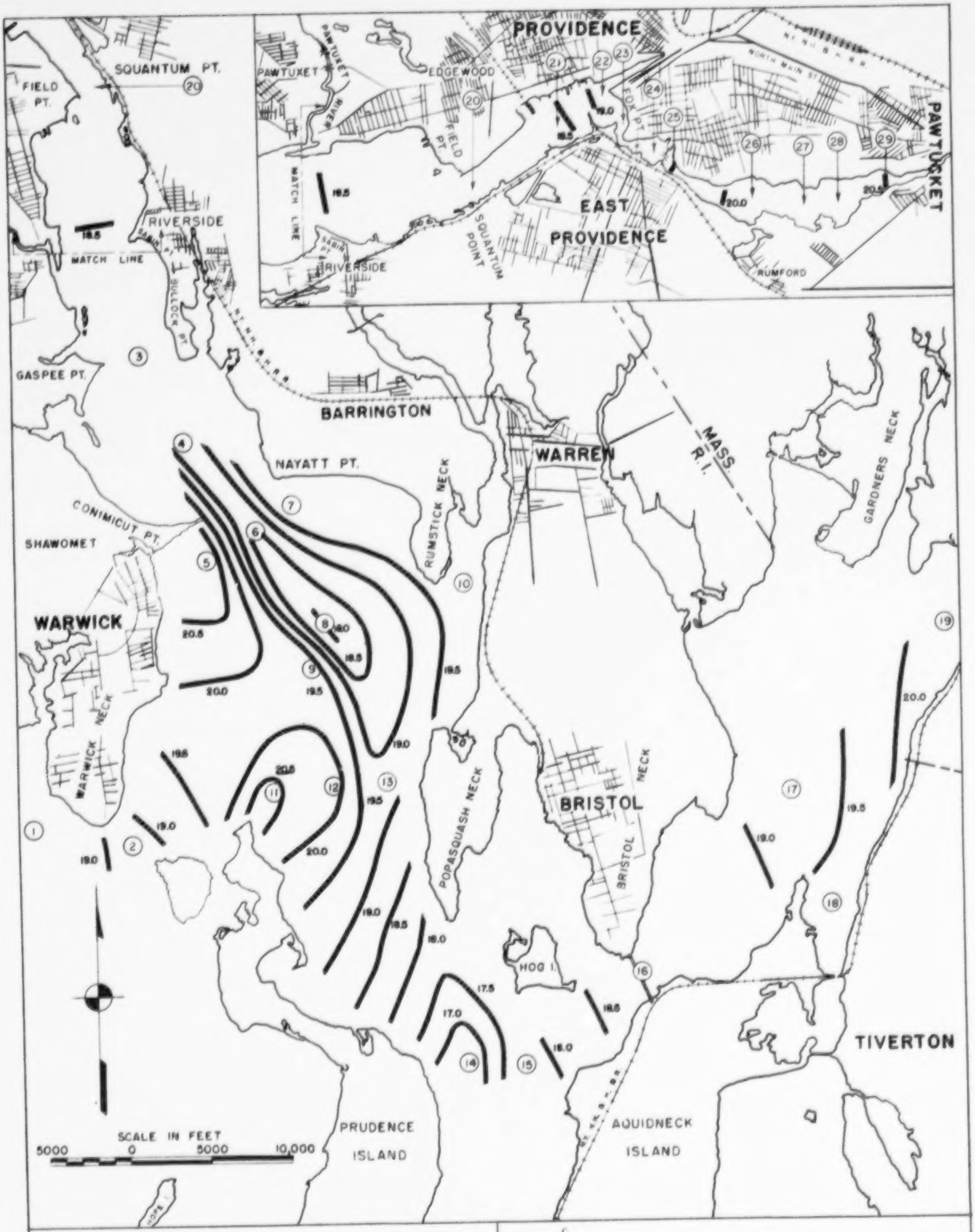
EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

34-g

FIGURE 19
ISOTHERMS (°C)
AT HIGH WATER + 9.3 HOURS

SURFACE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EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

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34-h

FIGURE 19
ISOTHERMS (°C)
AT HIGH WATER + 9.3 HOURS
BOTTOM

probably the variation in water temperature throughout the year which contributes greatly to the bottom dissolved oxygen variations. This variation in water temperature would have little effect on the bottom chloride concentrations. As with chloride values, it should be remembered that the degree of variation between the bottom dissolved oxygen concentrations and surface dissolved oxygen concentrations is relatively small, (note differences between surface and bottom dissolved oxygen variations in Figure 7).

64. For both the surface and bottom, the effects of the lunar cycle and tidal cycle are present. Table B-2 indicates that the three cycle analysis accounted for an average per cent removal of about 43% (multiple correlation coefficient of 0.65) for the surface, and about 57% removal (correlation coefficient of 0.75) for the bottom. It is seen then, that about half of the total dissolved oxygen variation is due to causes not implied by the three time cycles chosen. Figures 20 and 21 present some of the dissolved oxygen analyses where the computed values are compared with the observed values. It can be seen that the analysis in general was unable to account for rapid changes in dissolved oxygen although the general trends were followed.

65. Average amplitude for the surface dissolved oxygen across a tidal cycle was about 1.0 ppm and for the bottom was about 0.5 ppm. The range around these averages varied from 0.0 to 1.9 ppm for the surface and from 0.0 to 1.0 for the bottom with the larger amplitudes occurring in the lower end of the Providence River and the upper end of Mount Hope Bay. Hence, the maximum deviation around a tidal cycle was as high as 3.8 ppm (twice the amplitude) for the surface and 2.0 ppm at the bottom. Across the lunar cycle average amplitudes at the surface were about 0.8 ppm and at the bottom about 0.5 ppm varying from 0.0 to 1.8 at the surface and from 0.0 to 1.1 at the bottom. It should be noted that these latter extremes did not necessarily occur at the same station during both the tidal and lunar cycle. The lower limit of 0.0 ppm in both cycles indicates that the results of the statistical analyses showed no significant tidal or lunar amplitude.

66. In order to more fully understand the nature of the total dissolved oxygen variation, some crude estimates of the power spectrum at stations #17 and #20 were made. Additional power spectral estimates were computed on the rainfall and % sunshine series indicated in Figure 4. A comparison of these estimates indicated that the occurrence of rainfall during the survey may have had a decided effect on the variation in dissolved oxygen at the two stations. There did not appear to be any

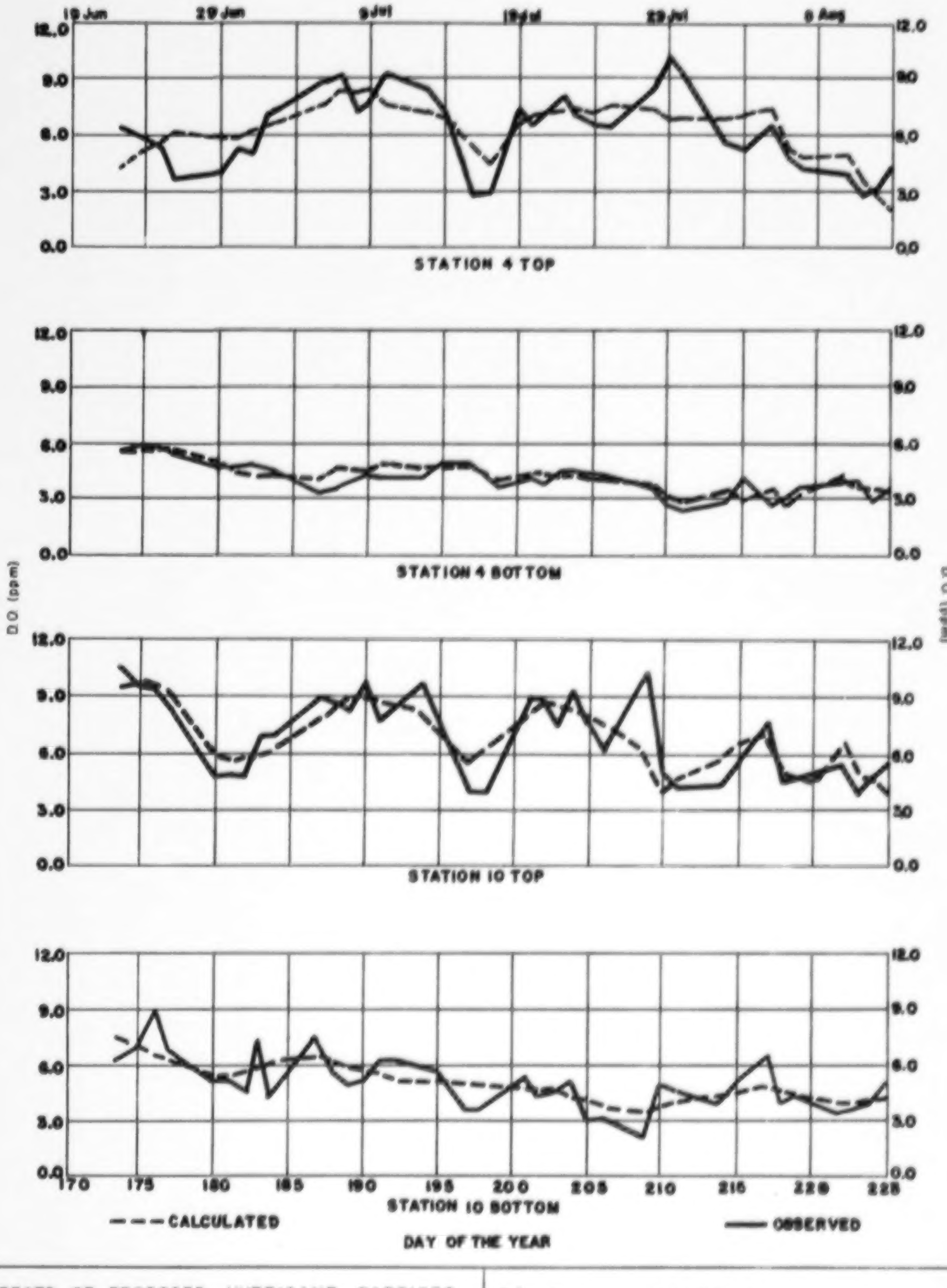
relationship between the % sunshine and the dissolved oxygen. It should be remembered, however, that variations in dissolved oxygen during a 24 hour period could not be tested. The dissolved oxygen spectral estimates at stations #17 and #20 did not appear to show any long term trends although a considerable length of record would be needed to fully confirm this supposition.

67. Figures 22 through 25 present the dissolved oxygen isopleths at four stages of the tidal cycle under average lunar conditions. As with the previous figures for chlorides and temperatures, the location of any given isopleth varies depending on the time of the lunar month. Hence, additional sketches could be prepared at various times of the lunar month. Table B-7 and B-8 in Appendix B present the computed values at the four stages of the tide (from which Figures 22 through 25 were prepared) as well as computed values around four stages of the lunar cycle.

68. It is difficult to ascertain from Figures 22-25 whether a two-layer system exists with respect to dissolved oxygen although in certain areas (e. g. vicinity of station #6) it appears that the surface and bottom layers are moving in opposite directions. The more diffuse picture presented by the dissolved oxygen is probably due in part to the additional factors which can affect this variable such as the migration of algal blooms during a tidal cycle and the biochemical oxidation of organic matter. However, some interesting observations can be made.

69. It can be noted in Figure 24 bottom that the result of apparent flooding at station #10 into the Upper Bay area has reduced lateral stratification to a minimum along the route given by stations #10, #9, and #2. Vertical mixing at station #10 appears to be quite pronounced. The effect of flooding from stations #10 and #2 does not appear on the surface until approximately 3 hours later, as can be seen from Figure 25, surface. Figure 25, bottom does tend to continue the pattern established at HW + 6.2 hours although not as pronounced. The complex nature mentioned previously in the upper end of East Passage also appears to exist for dissolved oxygen.

70. It is interesting to note the differences in longitudinal dissolved oxygen gradients in Mount Hope Bay between the surface and bottom.



EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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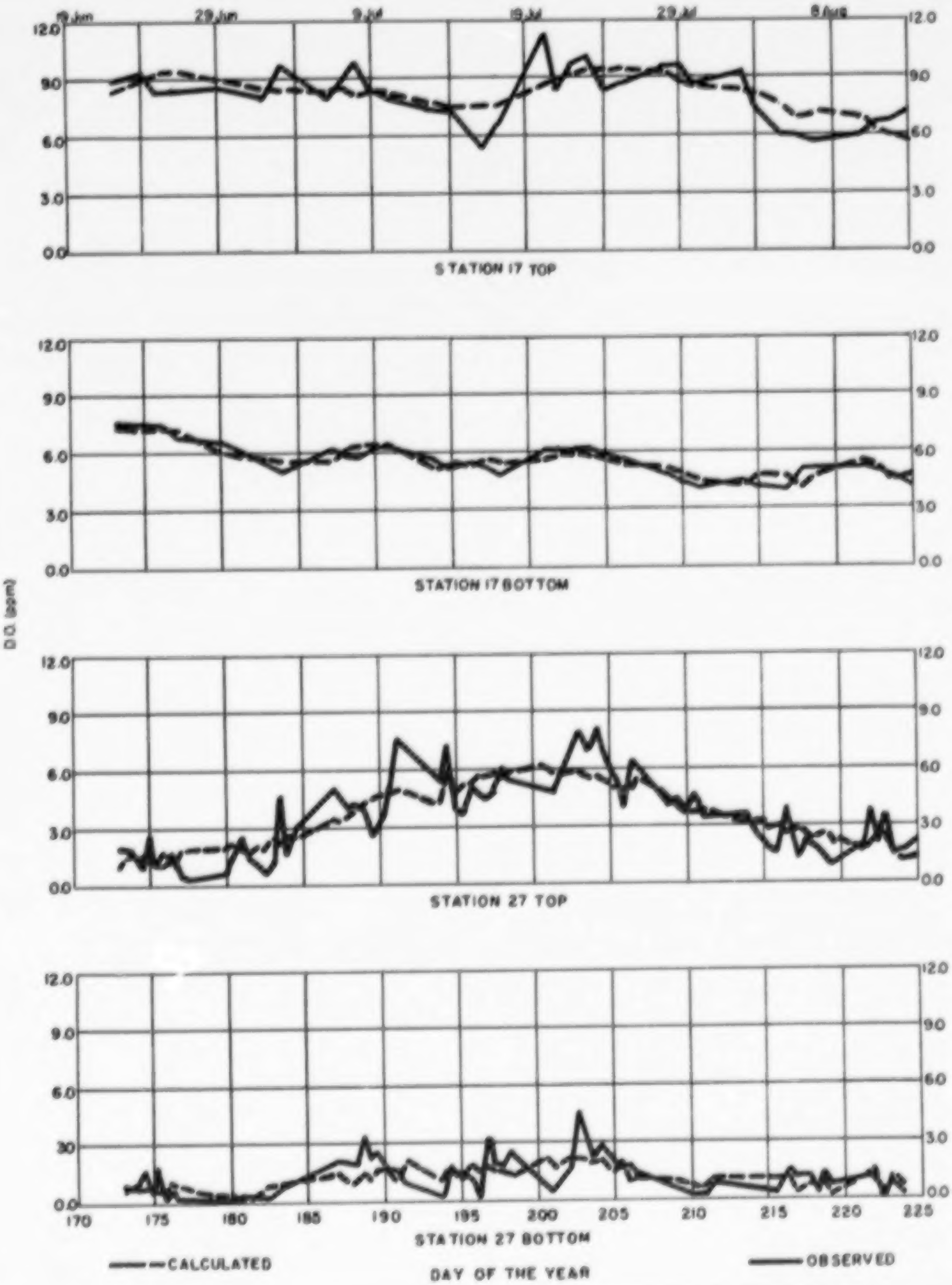
FIGURE 20

DISSOLVED OXYGEN

OBSERVED VERSUS CALCULATED

DURING 1959 SURVEY



EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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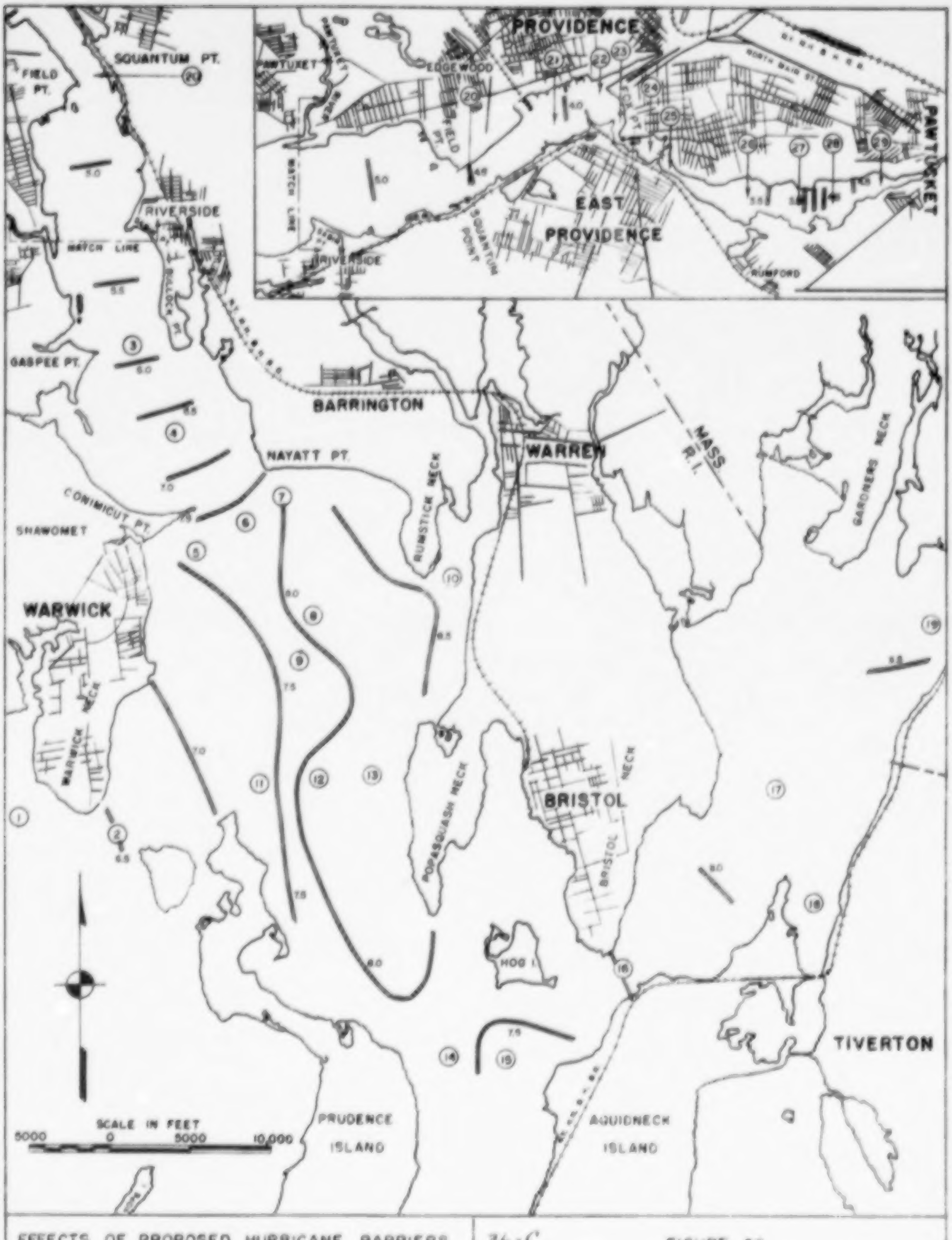
36-b

FIGURE 21
DISSOLVED OXYGEN
OBSERVED VERSUS CALCULATED
DURING 1959 SURVEY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EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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36-C

FIGURE 22
DISSOLVED OXYGEN ISOPLETHS (ppm)
AT HIGH WATER + 0.0 HOURS
SURFACE

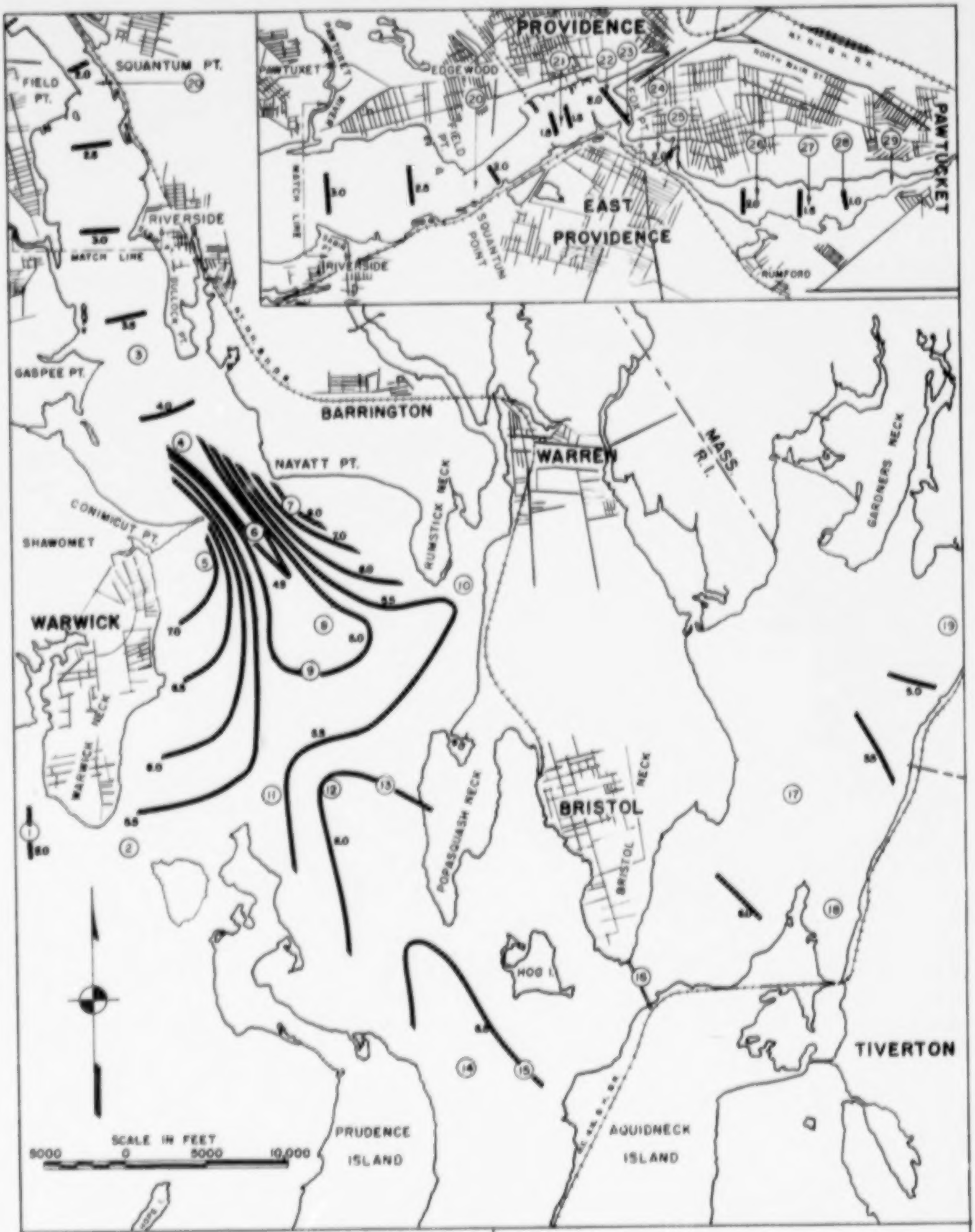
PROVIDENCE
EAST PROVIDENCE
PAWTUCKET
PAWTUXET
EDGEWOOD
RUMFORD
SQUANTUM PT.
FIELD PT.
RIVERSIDE
MATCH LINE
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS
R.I.
GARDINERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
SCALE IN FEET
5000
0
5000
10,000

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FIGURE 22
DISSOLVED OXYGEN ISOPLETHS (ppm)
AT HIGH WATER + 0.0 HOURS
BOTTOM

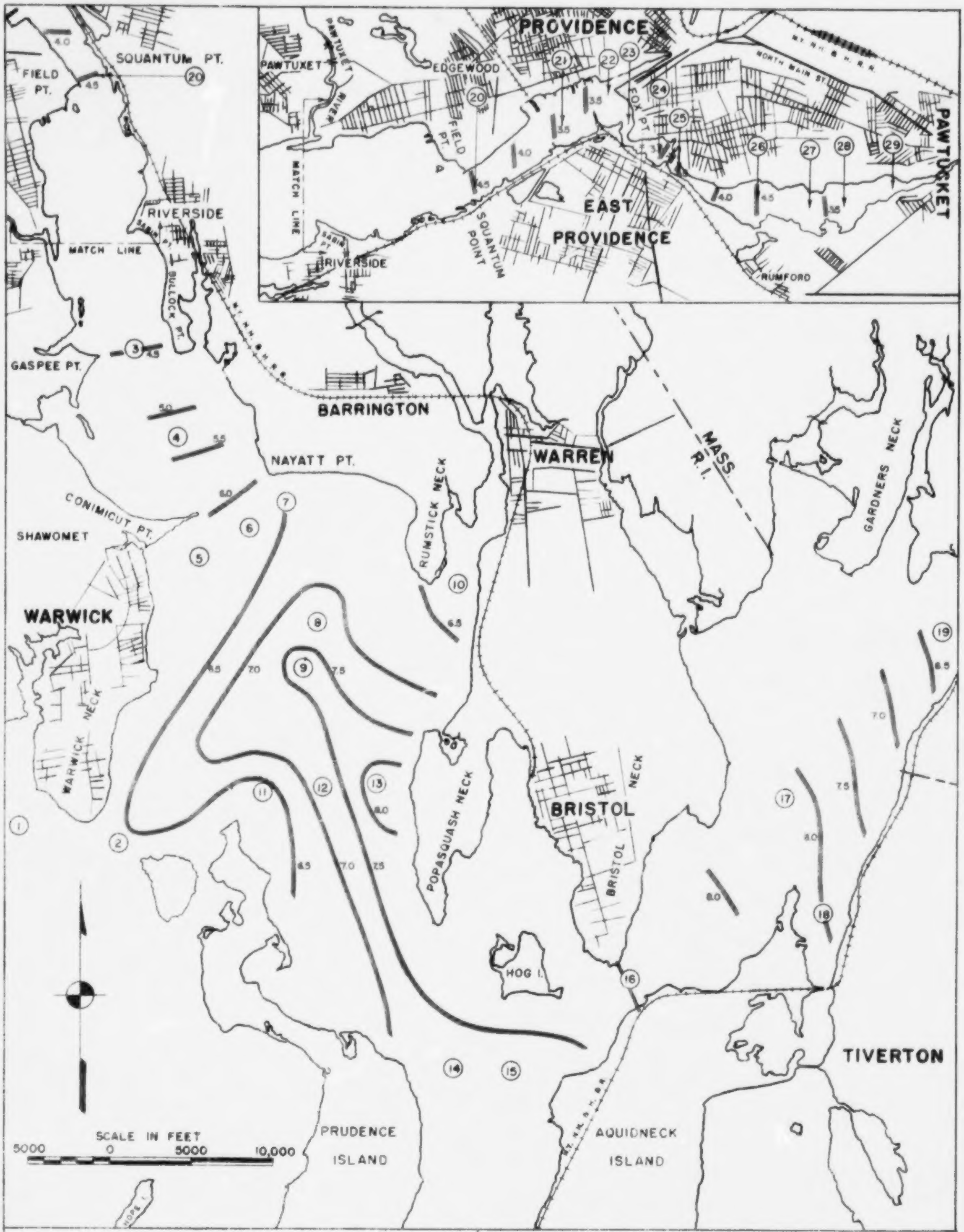
PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
PAWTUCKET
MATCH LINE
EAST PROVIDENCE
RUMFORD
SQUANTUM POINT
SABIN PT.
RIVERSIDE
SQUANTUM PT.
FIELD PT.
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
SCALE IN FEET
5000 0 5000 10,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 3.5

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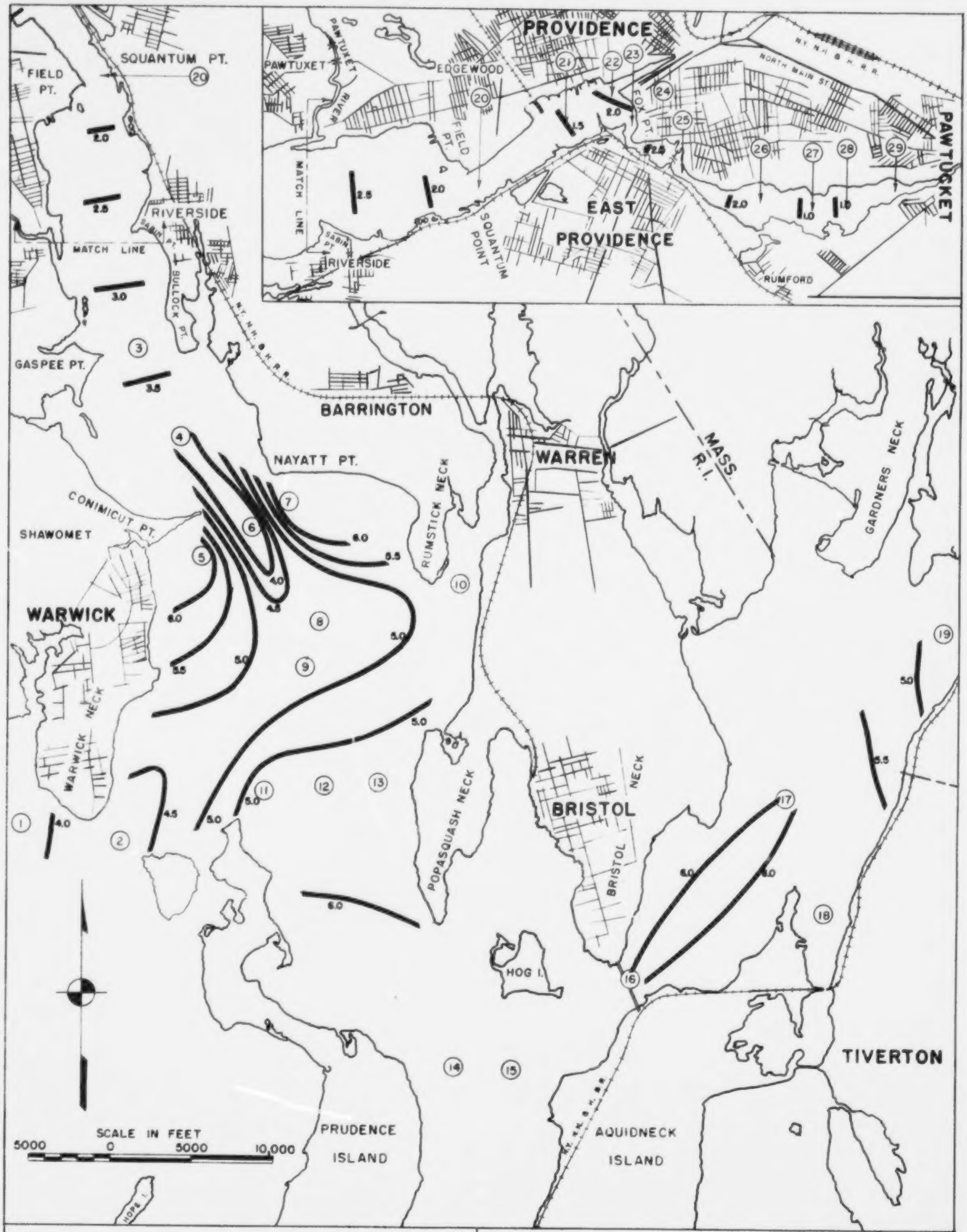
FIGURE 23
DISSOLVED OXYGEN ISOPLETHS (ppm)
AT HIGH WATER + 3.1 HOURS

SURFACE


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
MATCH LINE
SABIN PT.
RIVERSIDE
SQUANTUM POINT
EAST PROVIDENCE
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
FOX PT.
RUMFORD
PAWTUCKET
20
21
22
23
24
25
26
27
28
29
2.5
2.0
1.5
2.0
2.0
2.0
1.0
1.0
FIELD PT.
SQUANTUM PT.
RIVERSIDE
MATCH LINE
BULLOCK PT.
GASPEE PT.
N.Y. N.H. & H. R.R.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
SCALE IN FEET
5000
0
5000
10,000

EFFECTS OF PROPOSED HURRICANE BARRIERS
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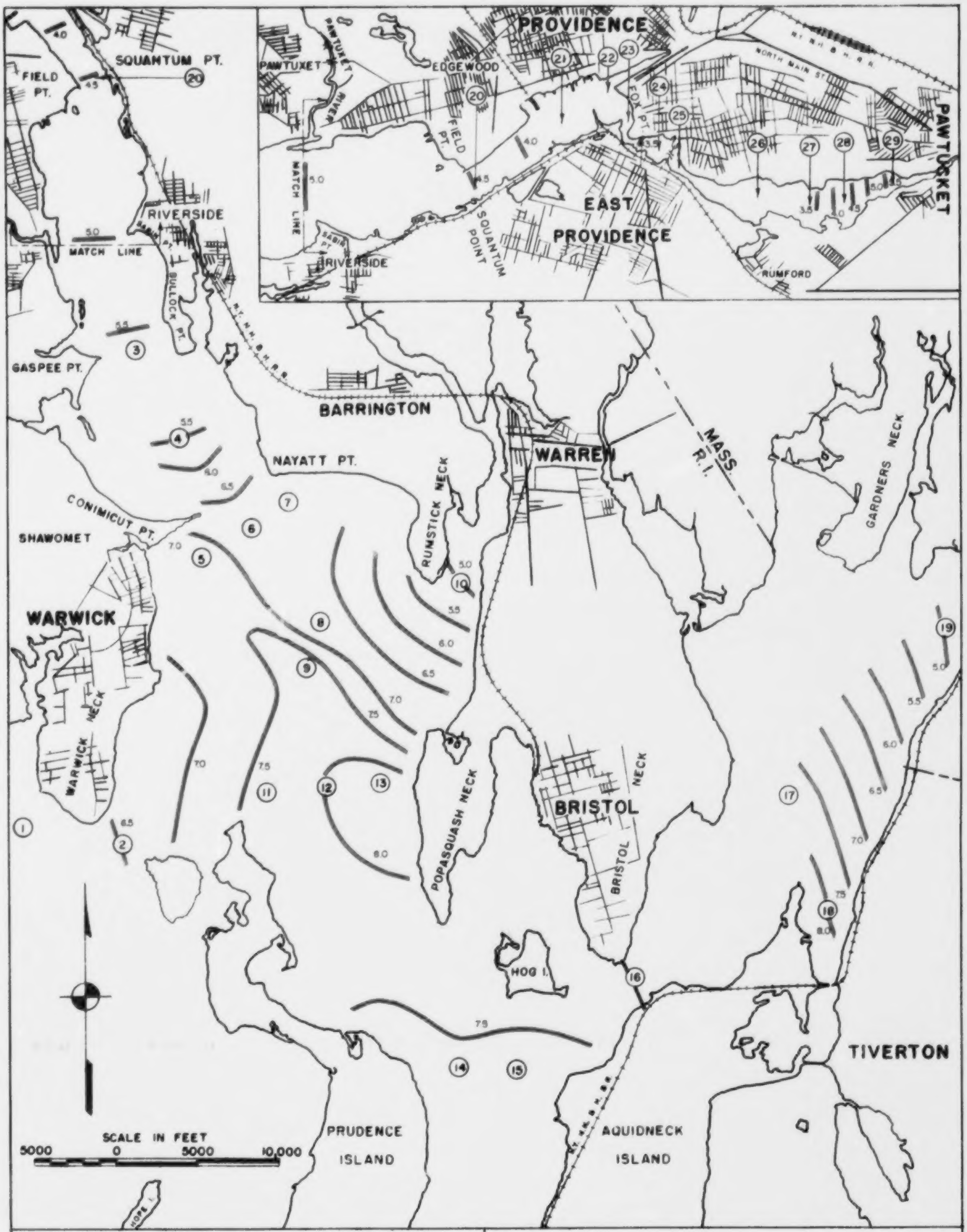
PUBLIC HEALTH SERVICE

36-7

FIGURE 23
DISSOLVED OXYGEN ISOPLETHS (ppm)
AT HIGH WATER + 3.1 HOURS

BOTTOM


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
PAWTUCKET
EAST PROVIDENCE
SQUANTUM POINT
RIVERSIDE
SABIN PT.
RUMFORD
MATCH LINE
SQUANTUM PT.
FIELD PT.
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
N.Y., N.H. & H.R.R.
SCALE IN FEET
5000 0 5000 10,000
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
3.5
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

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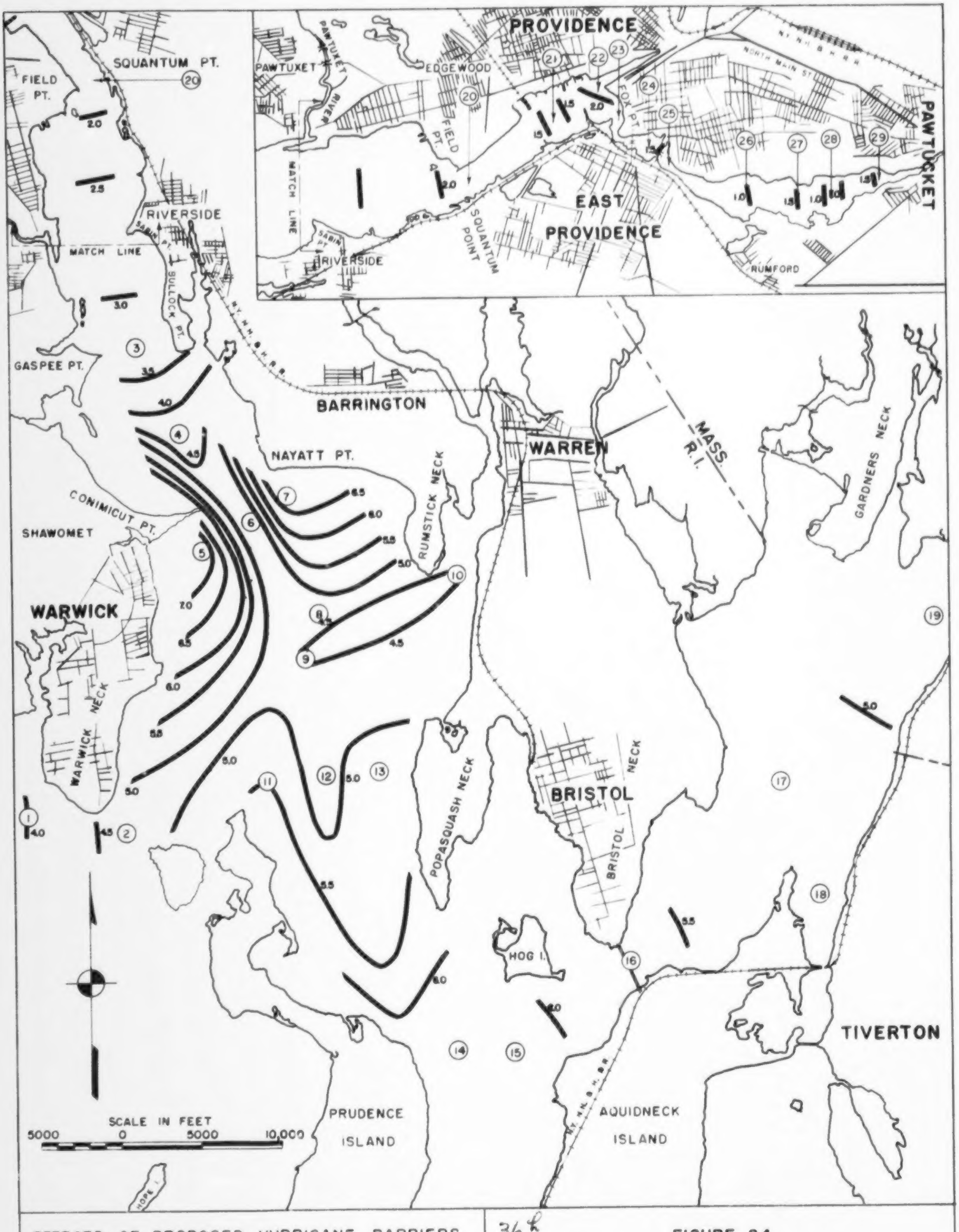
FIGURE 24
DISSOLVED OXYGEN ISOPLETHS (ppm)
AT HIGH WATER + 6.2 HOURS

SURFACE


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
PAWTUCKET
MATCH LINE
EAST PROVIDENCE
SQUANTUM POINT
SABIN PT.
RIVERSIDE
RUMFORD
20
21
22
23
24
25
26
27
28
29
1.5
1.5
2.0
2.0
1.5
1.0
1.5
1.0
2.0
1.5
SQUANTUM PT.
FIELD PT.
2.0
2.5
RIVERSIDE
SABIN PT.
MATCH LINE
BULLOCK PT.
3.0
GASPEE PT.
3
3.5
4.0
4
4.5
BARRINGTON
NAYATT PT.
7
6.5
6.0
5.5
5.0
6
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
CONIMICUT PT.
SHAWOMET
5
10
8
4.5
9
4.5
WARWICK
7.0
6.5
6.0
5.5
5.0
WARWICK NECK
6.0
11
12
5.0
13
POPASQUASH NECK
BRISTOL
BRISTOL NECK
17
19
5.0
1
4.0
4.5
2
5.5
6.0
HOG I.
16
5.5
18
6.0
14
15
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
SCALE IN FEET
5000
0
5000
10,000

EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

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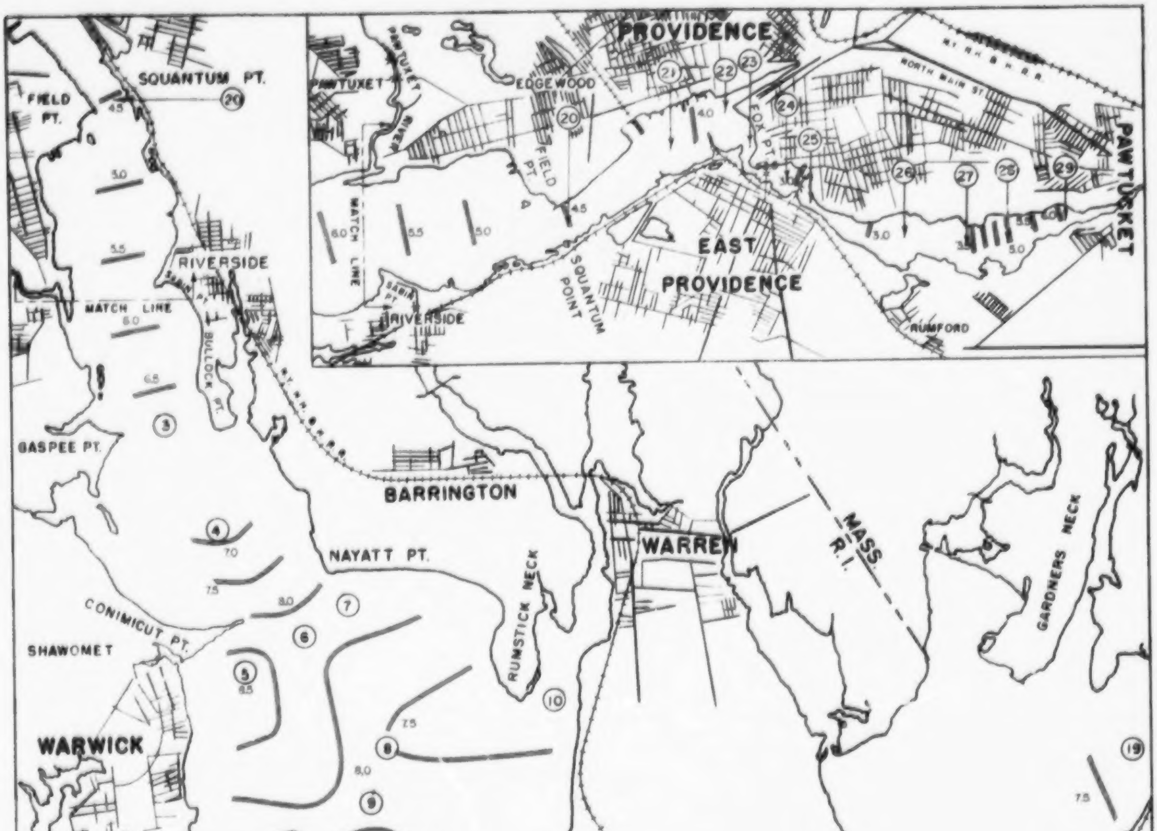
PUBLIC HEALTH SERVICE

36 h

FIGURE 24
DISSOLVED OXYGEN ISOPLETHS (ppm)
AT HIGH WATER + 6.2 HOURS
BOTTOM


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
MATCH LINE
SABIN PT.
RIVERSIDE
SQUANTUM POINT
EAST PROVIDENCE
NORTH MAIN ST.
FOX PT.
RUMFORD
PAWTUCKET
SQUANTUM PT.
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
SCALE IN FEET
5000
0
5000
10,000
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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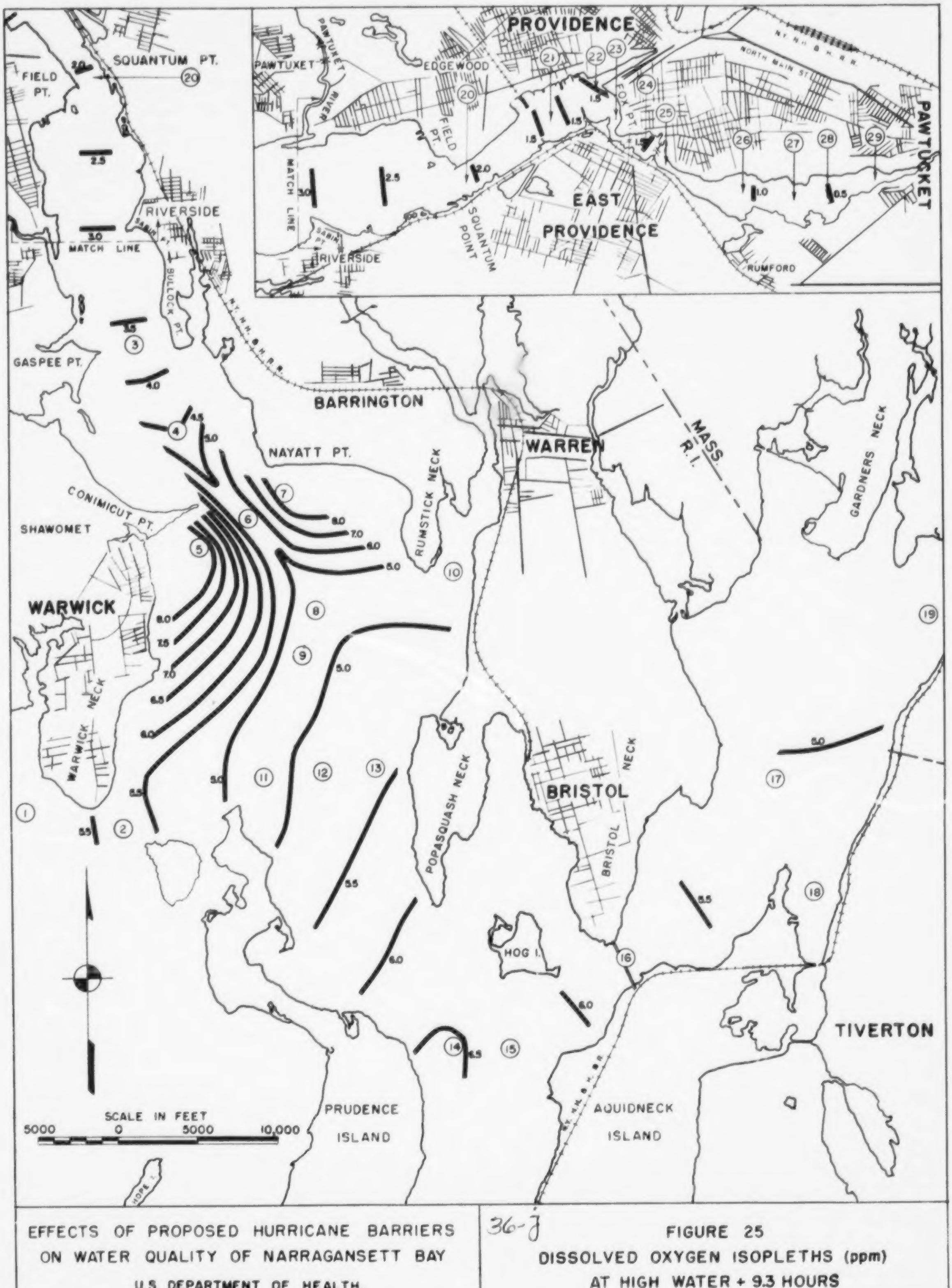
36-e

FIGURE 25
DISSOLVED OXYGEN ISOPLETHS (ppm)
AT HIGH WATER + 9.3 HOURS
SURFACE


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
PAWTUCKET
EAST PROVIDENCE
RUMFORD
SQUANTUM POINT
RIVERSIDE
SABIN PT.
MATCH LINE
SQUANTUM PT.
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDINERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
N.Y. N.H. & H. R.R.
SCALE IN FEET
5000 0 5000 10,000

EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

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36-J

FIGURE 25
DISSOLVED OXYGEN ISOPLETHS (ppm)
AT HIGH WATER + 9.3 HOURS
BOTTOM

For the surface, there is a period of pronounced surface longitudinal gradient during the period from HW + 3.1 hours to HW + 6.2 hours (Figures 23 and 24). The gradient does not exist during the remaining portion of the tidal cycle although the level of dissolved oxygen at station #19 has increased about 2.0 ppm. For the bottom there is, in general, a complete lack of any longitudinal gradient in this area throughout the entire tidal cycle.

71. Summary of conclusions Summarizing the preceding discussion, the following conclusions may be drawn.

a) "High" and "low" values of surface dissolved oxygen may occur at various times during the year reflecting the influence of aperiodic meteorological influences. Average amplitude for dissolved oxygen at the surface during a tidal cycle is about 1.0 ppm and during a lunar cycle about 0.8 ppm.

b) The dissolved oxygen of the bottom waters is influenced considerably by the time of year reflecting the influence of water temperature which apparently does not markedly affect the surface dissolved oxygen. Average amplitude for the bottom dissolved oxygen during a tidal cycle was about 0.5 ppm and for a lunar cycle was about 0.5 ppm.

c) Power spectrum estimates of the surface dissolved oxygen at two stations (#20 and #17) indicate that rainfall during the 1959 survey may be a contributing factor in the variation in dissolved oxygen.

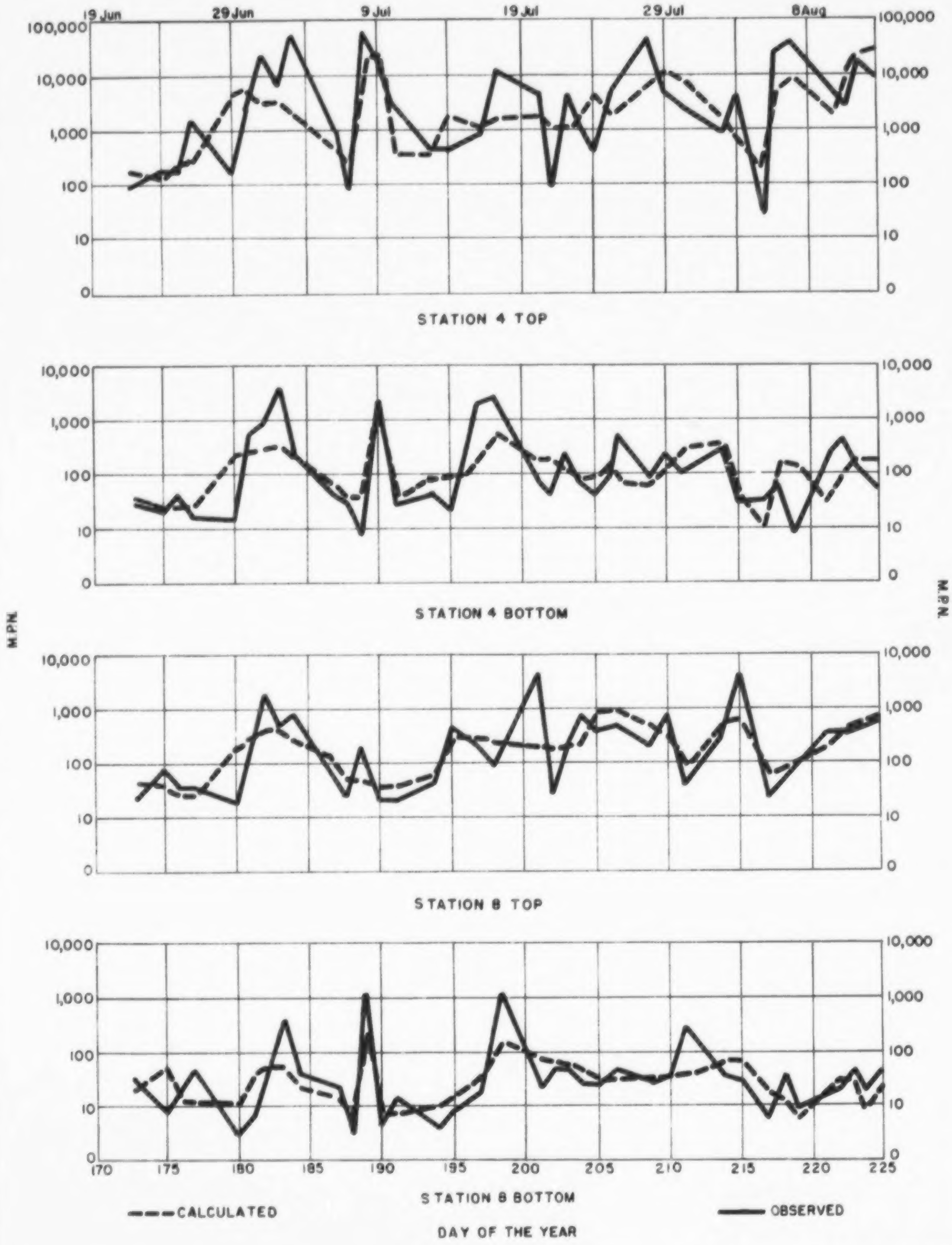
d) It appears that at some stations the dissolved oxygen pattern follows a two-layered system although this is not as marked as for the chloride variations.

72. Results of analyses of MPN data Qualitative indications of the results of the sinusoidal analysis of the MPN data are given in Table 6. The results appear similar to those obtained from the dissolved oxygen analyses. Again, the seasonal influence on the Most Probable Number of coliform organisms does not appear to be predominant. At station #17, data was available for other times of the year besides the two month survey period. The results of the sinusoidal analysis on these data plus the data collected during June to August of 1959 again do not indicate a predominant seasonal cycle. Therefore, "high and low" MPN values at a given station may be expected to occur at different times during the year and without any marked degree of regularity.

73. As shown in Table 6, the greatest influence of the three cycles on the MPN count is the tidal one, indicating the effect of water movement on the MPN. In general, this is true also for the bottom MPN. Table B-2 in Appendix B indicates that a considerable portion of the total MPN variation is due to causes other than those implied by the three-cycle analysis. The average per cent removal of the total variation for the surface MPN was about 25% (correlation coefficient of 0.50) and for the bottom MPN was about 33% (correlation coefficient of 0.57). At seven of the surface stations and three of the bottom stations, no significant relationship appears to exist between the MPN and the three cycles. In general, then, the greatest portion of the total MPN variation is due to causes other than those implied by the three-cycle analysis. Since the entire analysis of the MPN data was made on a logarithmic basis, average amplitudes during a tidal and lunar cycle for the surface and bottom cannot be giver per se. However, Tables B-9 and B-10 in Appendix B which give the calculated values of the MPN at various times of the tidal and lunar cycle can be consulted.

74. The phase angle relationships for the surface MPN indicate that along the route given by stations #3-4-6-9-12-13-15, maximum MPN counts occur at approximately low water. At the surface at the remaining stations in the Upper Bay area, maximum MPN counts occur approximately 2-4 hours after the time of high water. In the Mount Hope Bay area, maximum surface MPN counts occur at stations #17 and #19 at low water while at station #18, maximum counts occur at about 2 hours before low water.

75. An analysis of the phase angle relationships for the bottom MPN indicates that in general, maximum MPN counts occur 2-3 hours sooner than on the surface except at stations #14 and #15, where the time of maximum is about the same as on the surface. In the Mount Hope Bay area, maximum MPN counts at stations #18 and #19 occur almost at high water (6 hours later than for the surface) while at station #17 maximum MPN counts occur at approximately the same time for both the surface and bottom. This does not appear to indicate the marked two-layered system for MPN as was present for chlorides although the fact that maximums did not occur at the same time at all stations for the surface and bottom does provide an indication of the complex mixing patterns existing in the Bay.



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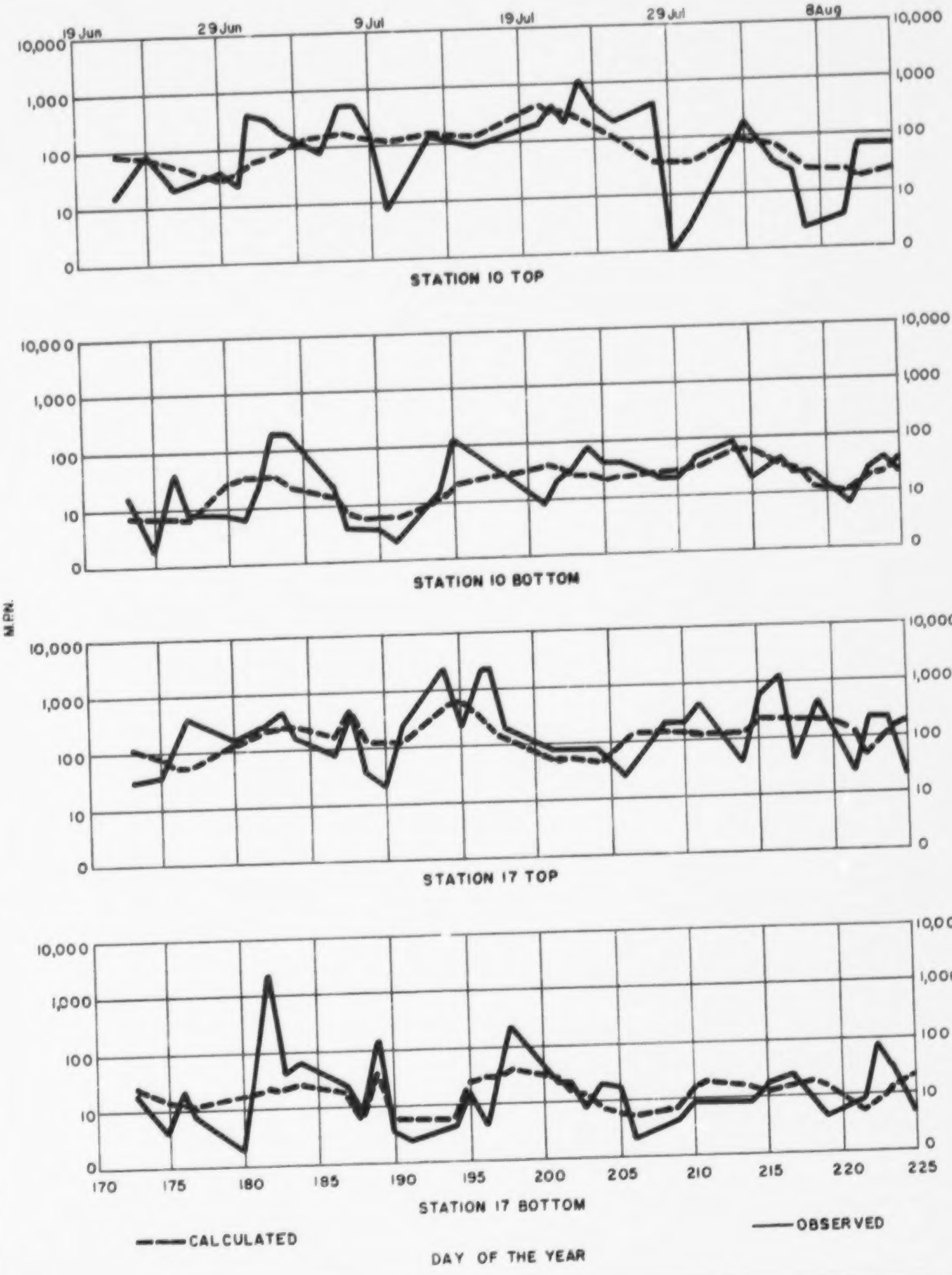
38-a

FIGURE 26

MOST PROBABLE NUMBER
OBSERVED VERSUS CALCULATED
DURING 1959 SURVEY



EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

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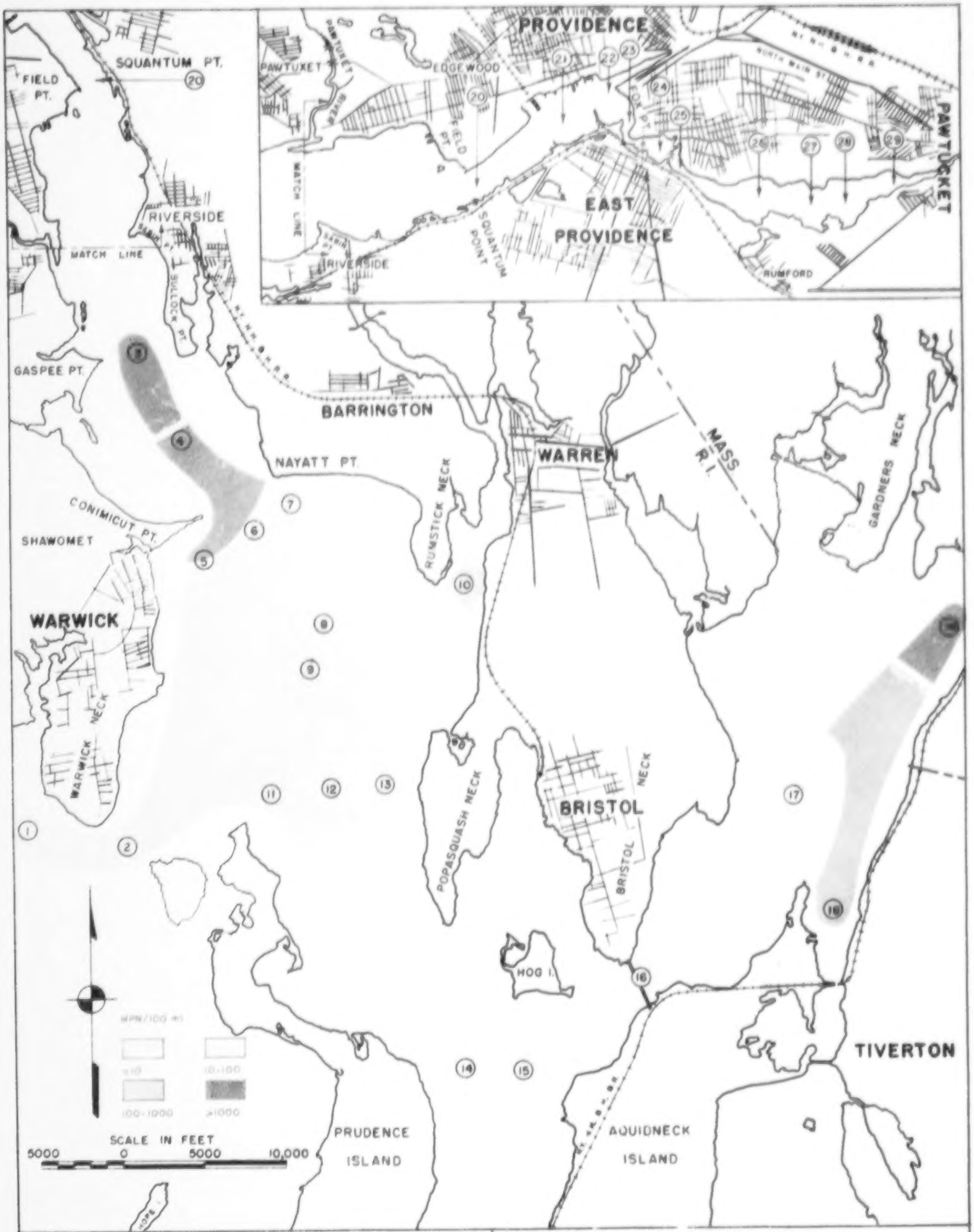
PUBLIC HEALTH SERVICE

38-b

FIGURE 27

MOST PROBABLE NUMBER

OBSERVED VERSUS CALCULATED DURING 1959 SURVEY


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
EAST PROVIDENCE
PAWTUCKET
RUMFORD
SQUANTUM POINT
RIVERSIDE
MATCH LINE
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
SQUANTUM PT.
FIELD PT.
RIVERSIDE
MATCH LINE
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
MPN/100 ml
<10
10-100
100-1000
>1000
SCALE IN FEET
5000
0
5000
10,000

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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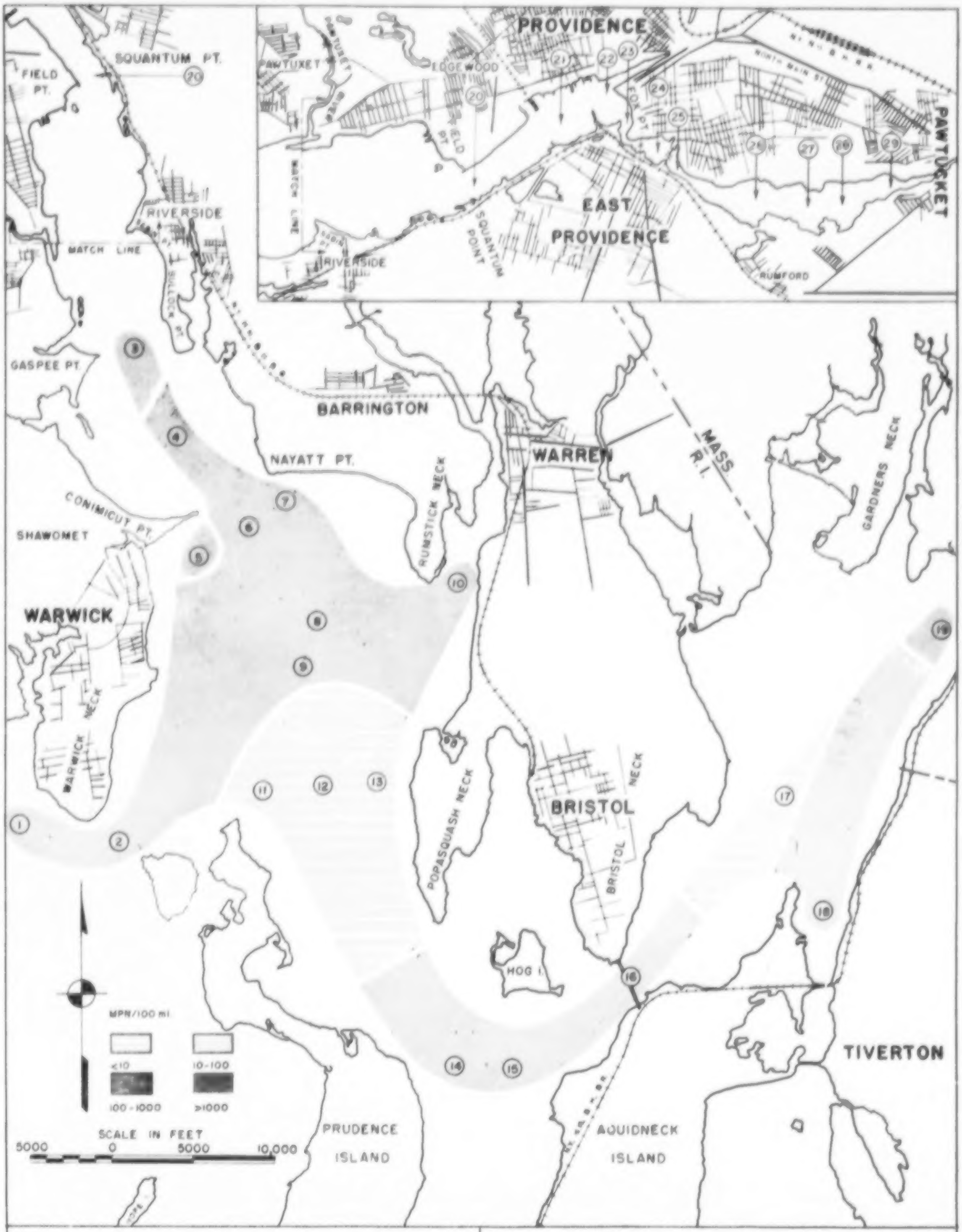
PUBLIC HEALTH SERVICE

FIGURE 28
MPN/100ml. ISOPLETHS
AT HIGH WATER + 0.0 HOURS
SURFACE


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
MATCH LINE
SQUANTUM POINT
RIVERSIDE
EAST PROVIDENCE
RUMFORD
PAWTUCKET
NORTH MAIN ST.
FIELD PT.
SQUANTUM PT.
RIVERSIDE
MATCH LINE
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
MPN/100 ml.
<10
10-100
100-1000
>1000
SCALE IN FEET
5000
0
5000
10,000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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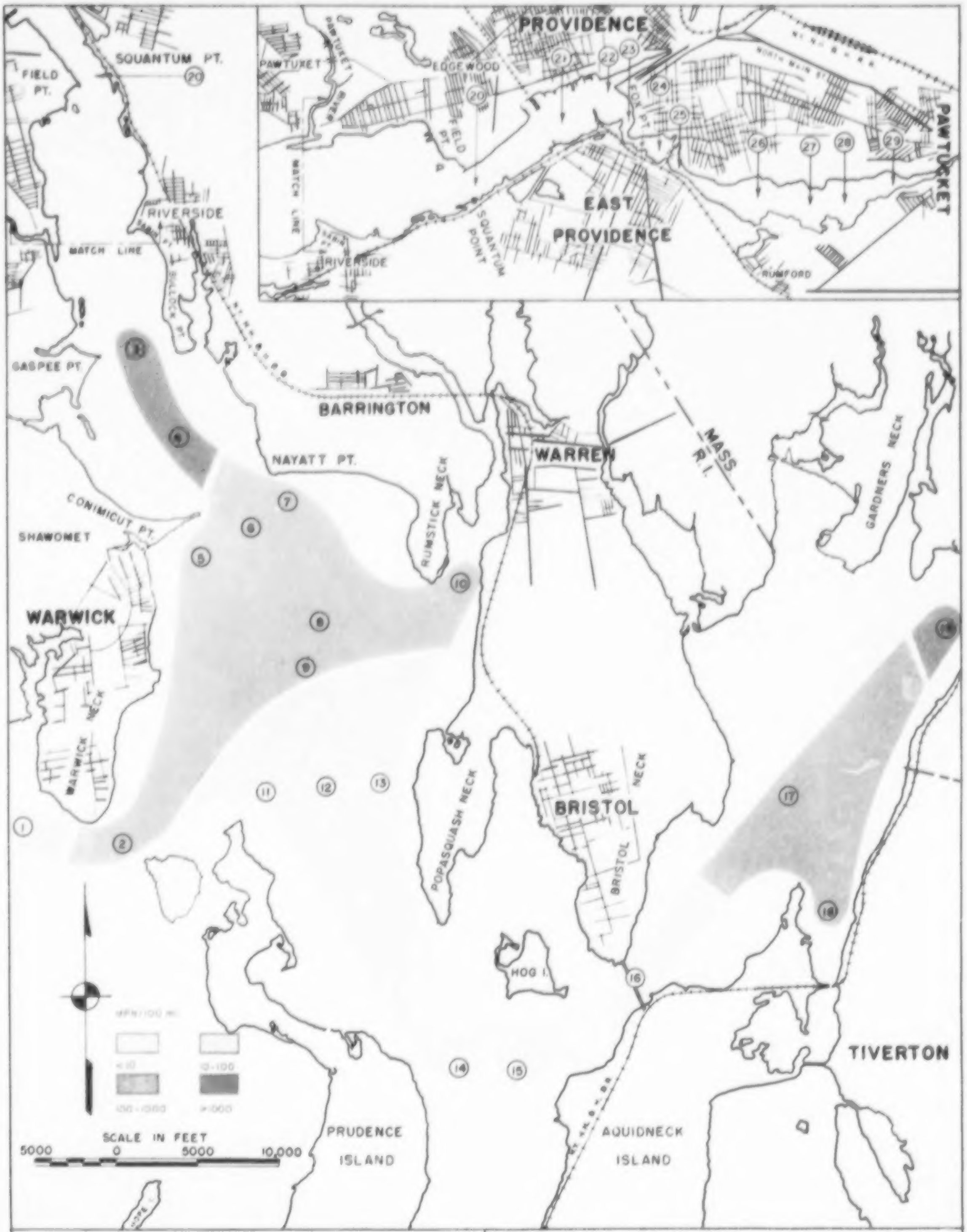
38-c

FIGURE 28
MPN/100ml. ISOPLETHS
AT HIGH WATER + 0.0 HOURS
BOTTOM


PROVIDENCE
PAWTUXET
PAWTUXET
EDGEWOOD
FIELD PT.
MATCH LINE
SQUANTUM POINT
RIVERSIDE
EAST PROVIDENCE
NORTH MAIN ST.
EDEN PT.
RUMFORD
PAWTUCKET
21
22
23
24
25
26
27
28
29
20
FIELD PT.
SQUANTUM PT.
RIVERSIDE
MATCH LINE
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
MPN/100 ml.
<10
10-100
100-1000
>1000
SCALE IN FEET
5000
0
5000
10,000

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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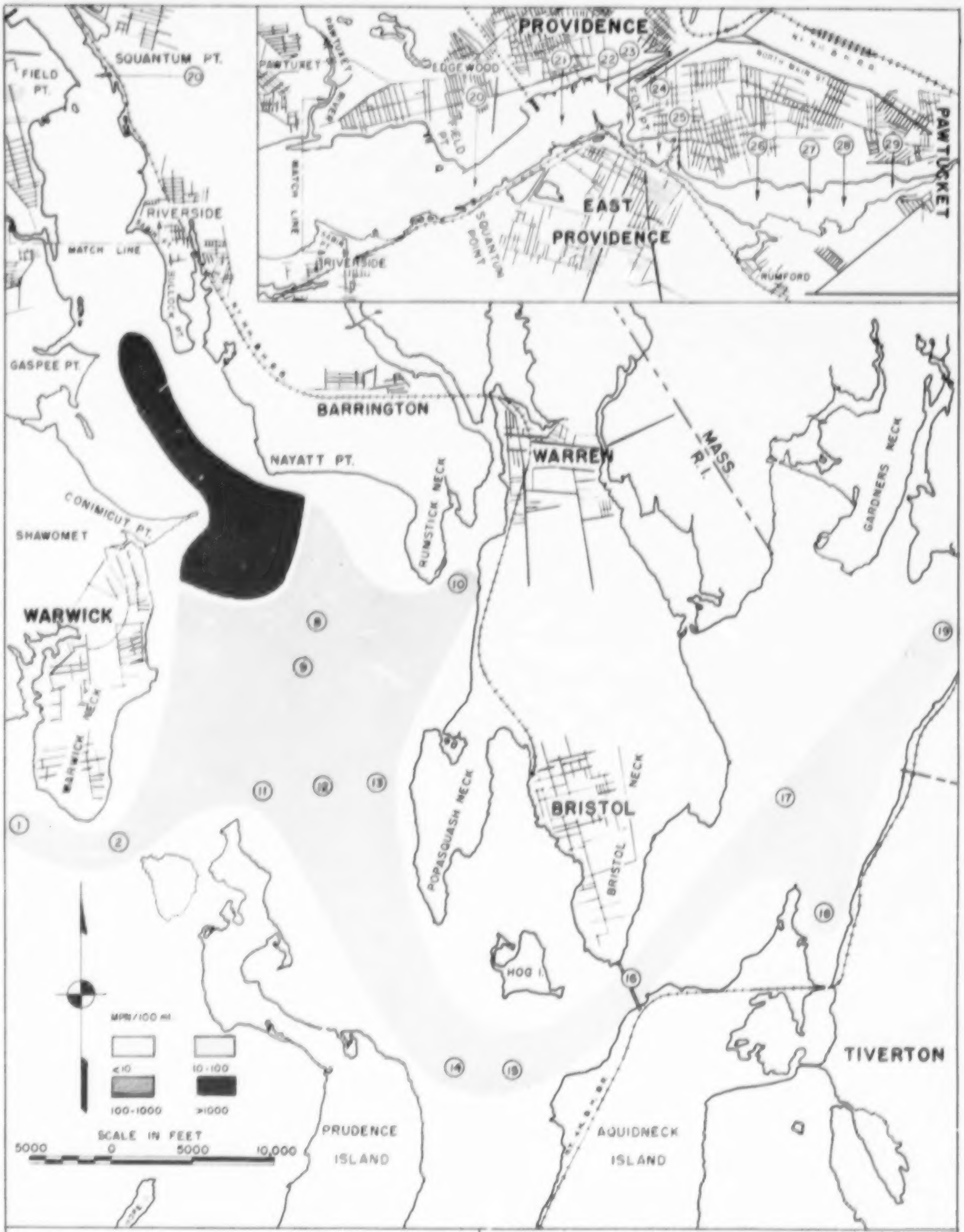
38-d

FIGURE 29
MPN/100ml. ISOPLETHS
AT HIGH WATER + 3.1 HOURS

SURFACE


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
SQUANTUM POINT
EAST PROVIDENCE
RUMFORD
PAWTUCKET
RIVERSIDE
MATCH LINE
SQUANTUM PT.
FIELD PT.
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE
MPN/100 ml
<10
10-100
100-1000
>1000
SCALE IN FEET
5000
0
5000
10,000
1
2
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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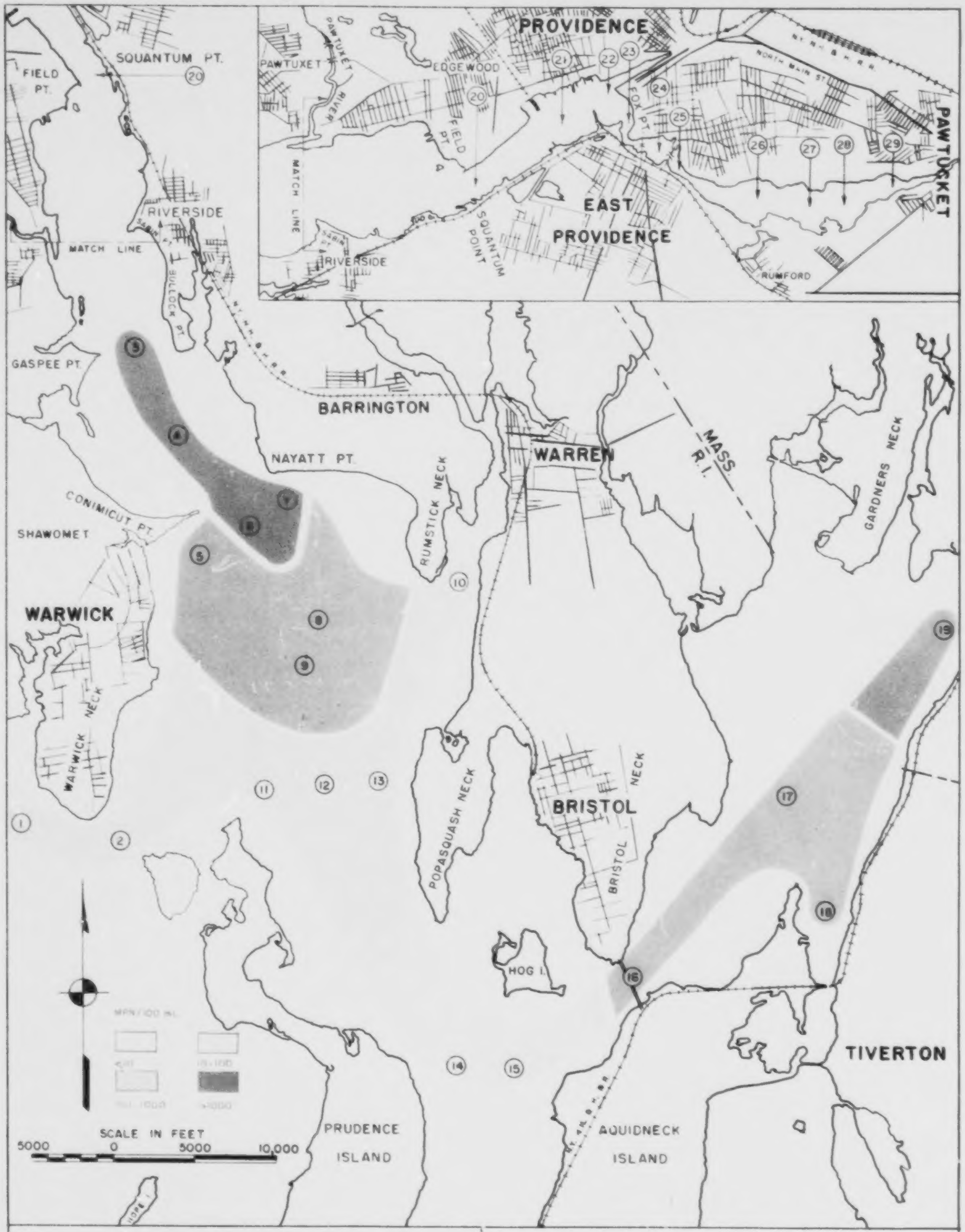
PUBLIC HEALTH SERVICE

38-a

FIGURE 29
MPN/100ml. ISOPLETHS
AT HIGH WATER + 3.1 HOURS

BOTTOM


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
MATCH LINE
SQUANTUM POINT
EAST PROVIDENCE
RIVERSIDE
SABIN PT.
EOX PT.
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
RUMFORD
PAWTUCKET
FIELD PT.
SQUANTUM PT.
RIVERSIDE
MATCH LINE
BULLOCK PT.
GASPEE PT.
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NAYATT PT.
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MASS.
R.I.
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POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
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10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
MPN/100 ML.
<10
10-100
101-1000
>1000
SCALE IN FEET
5000
0
5000
10,000

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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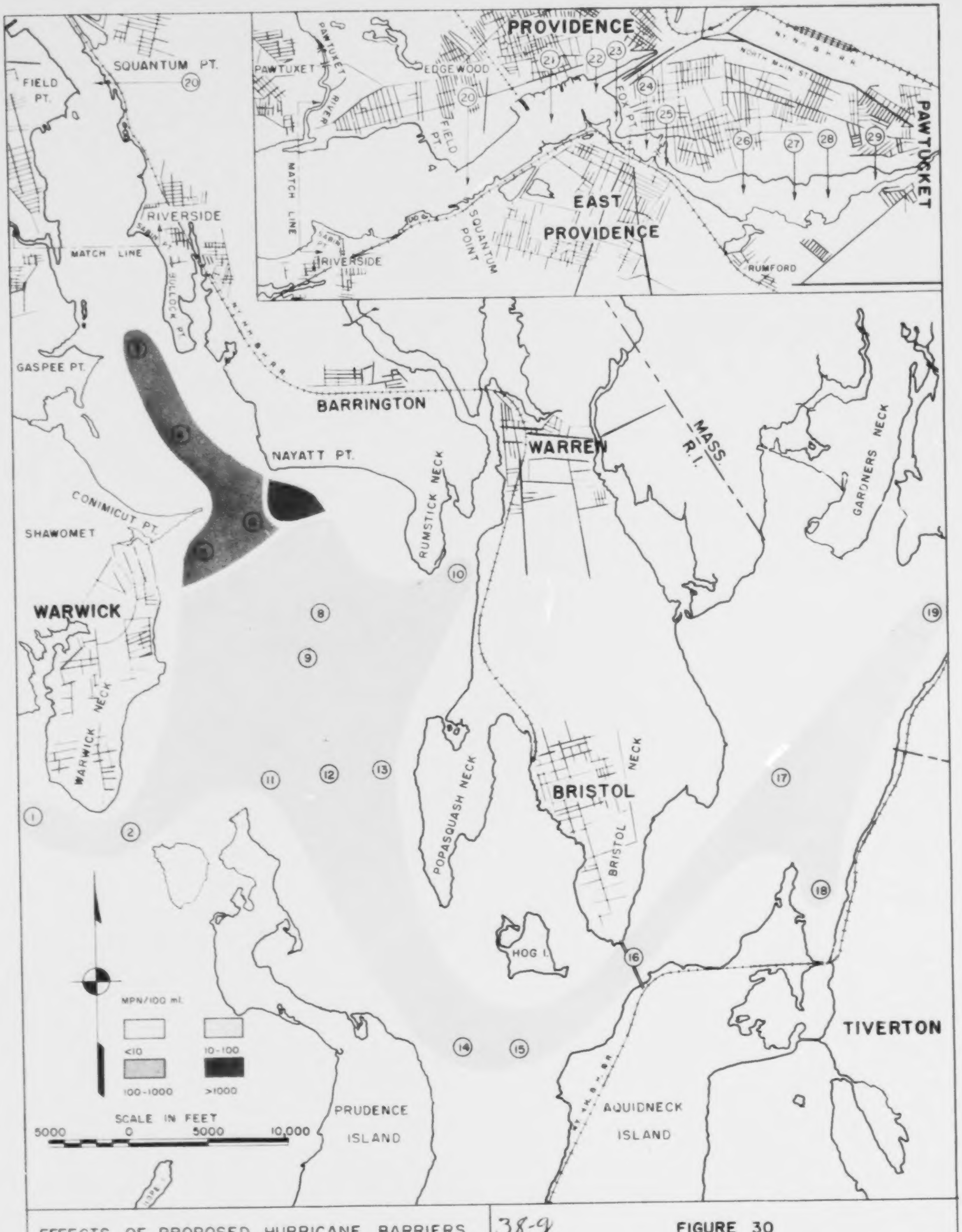
38-f

FIGURE 30
MPN/100ml. ISOPLETHS
AT HIGH WATER + 6.2 HOURS

SURFACE


PROVIDENCE
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FOX PT.
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EAST PROVIDENCE
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GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
1
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16
17
18
19
MPN/100 ml.
<10
10-100
100-1000
>1000
SCALE IN FEET
5000
0
5000
10,000

EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

U.S. DEPARTMENT OF HEALTH,
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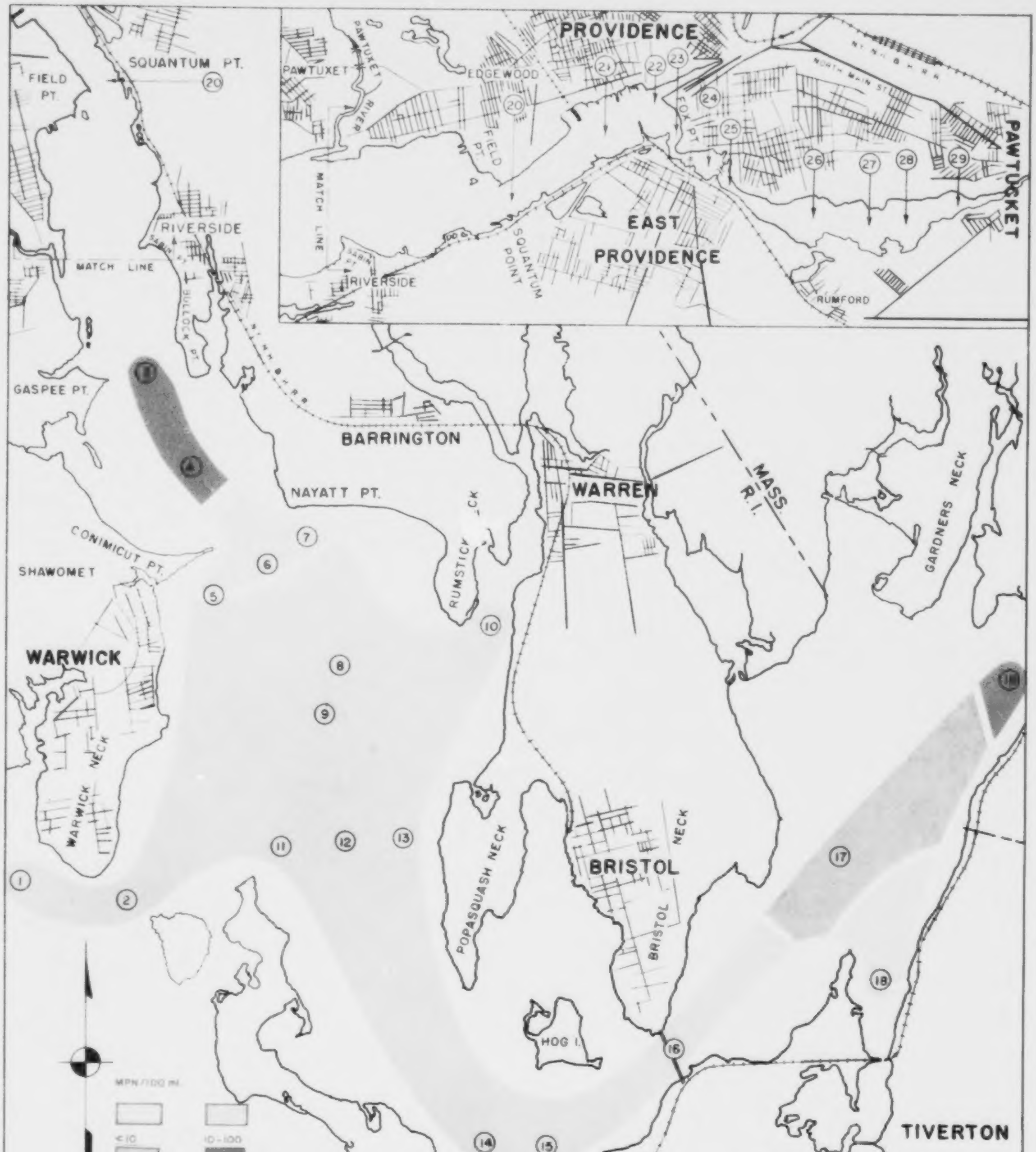
38-9

FIGURE 30
MPN/100ml. ISOPLETHS
AT HIGH WATER + 6.2 HOURS

BOTTOM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NAYATT PT.
CONIMICUT PT.
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RUMSTICK CK
WARREN
MASS.
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
MPN/100 ml.
<10
10-100
100-1000
>1000
SCALE IN FEET
5000
0
5000
10,000
1
2
3
4
5
6
7
8
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EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

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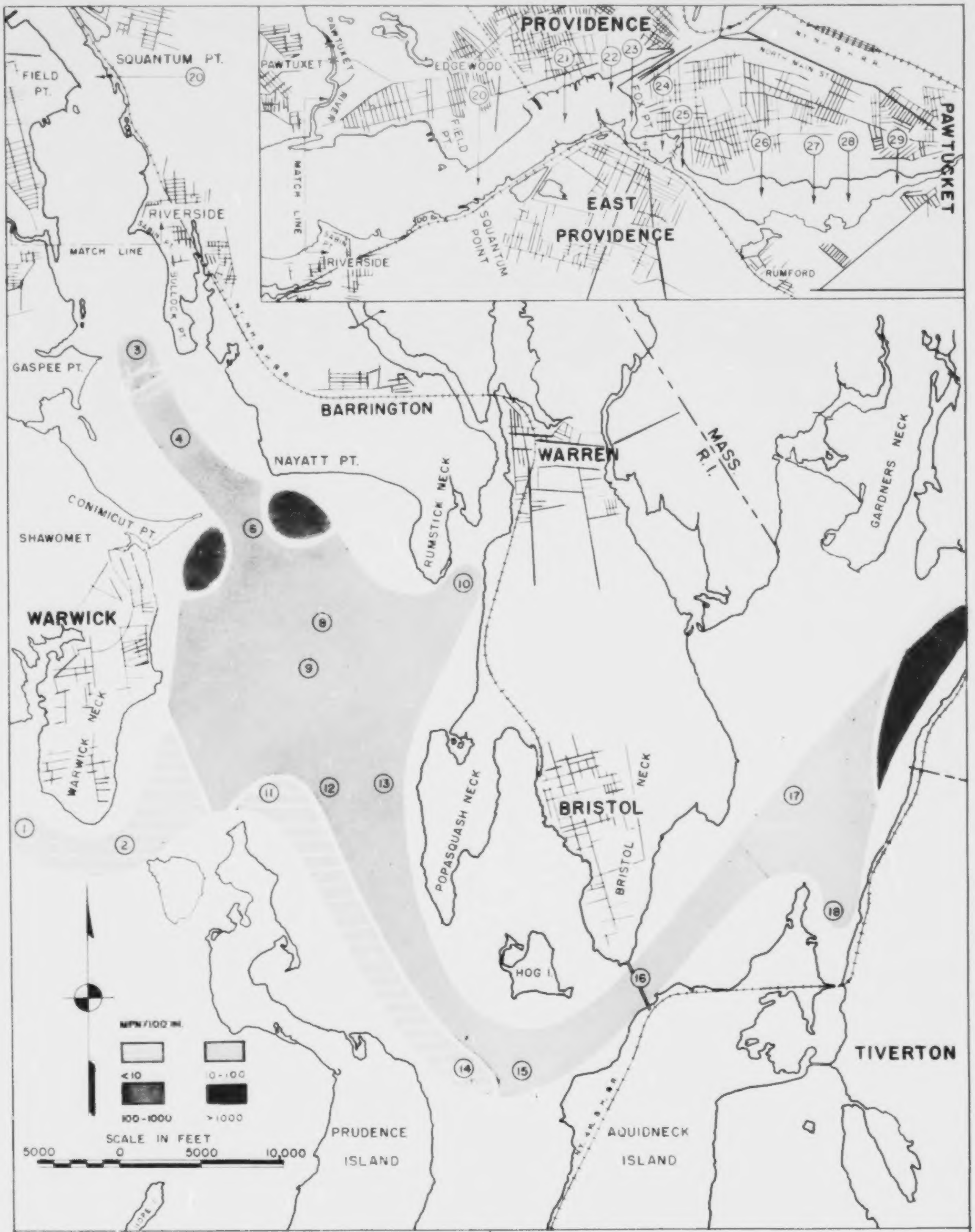
38-h

FIGURE 31
MPN/100ml. ISOPLETHS
AT HIGH WATER + 9.3 HOURS

SURFACE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POPASQUASH NECK
BRISTOL
BRISTOL NECK
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PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
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16
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18
MPN/100 ml.
<10
10-100
100-1000
>1000
SCALE IN FEET
5000
0
5000
10,000

EFFECTS OF PROPOSED HURRICANE BARRIERS
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38 i

FIGURE 31
MPN/100ml. ISOPLETHS
AT HIGH WATER + 9.3 HOURS

BOTTOM

76. Figures 26 and 27 present some examples of observed versus computed MPN values at various points in the study area. It can be seen that the greater portion of the total MPN variation is due to causes other than those implied by the sinusoidal analysis. As with the dissolved oxygen rapid changes in MPN were not described by the analysis although the general trends were portrayed.

77. In order to gain additional knowledge about the total variation in MPN and the factors which may cause these variations, power spectral estimates were made on the MPN at the surface of two stations: #6 and #17. These estimates together with the estimate of the rainfall power spectrum used in the dissolved oxygen analysis appeared to indicate that rainfall may have had an effect on the MPN variation at these two stations. Other estimates were made for river flow and pollution load but no completely satisfactory cause and effect relationships could be ascertained between these factors and the MPN.

78. A final analysis was made consisting of cross-correlations between the rainfall and the MPN at one station (#17). (See Appendix B for brief discussion of cross-correlation.) From this analysis, which again is only a crude estimate due to the nature of the data, it appears that high values of rainfall are followed by high values of MPN. This could be a result of storm water by-passes in nearby sewer systems where raw sewage would be discharged directly to the area during periods of high rainfall.

79. Figures 28-31 present the MPN ranges in the study area over a tidal cycle as determined from the results of the sinusoidal analysis. As with the other variables, these figures have been prepared under average lunar month conditions and changes (although relatively slight in this case) can occur depending on the time of the lunar cycle. An indication of these changes is given in Tables B-9 and B-10 in Appendix B. It can be seen from Figures 28-31 that the highest surface MPN range in the Upper Bay and Mount Hope Bay areas occurs during HW + 3.1 to HW + 6.2 hours. In Mount Hope Bay, it is interesting to note the general deflection of high counts into the Seekonk River. In general there is little relative change in the MPN range for the bottom waters. Figure 30, surface, indicates the channeling effect due to flooding from stations #2 and #10 into the Upper Bay area. At the same time, increased MPN counts

have penetrated beyond the Mount Hope Bay Bridge (station #16).

80. Summary of conclusions The following conclusions result from the preceding discussions:

a) In general, the seasonal effect on MPN is not predominant and "high and low" values at a station may be expected to occur at almost any time of the year.

b) Of the three cycles used in the sinusoidal analysis, the tidal cycle influence is the greatest although other causes (presumably) aperiodic meteorological causes) contribute significantly to the total variation. An average of 75% of the total surface MPN variation and 67% of the total bottom variation remains unexplained in a quantitative sense.

c) Rough estimates of the power spectrum at stations #6 and #17 and an estimate of the cross-correlation between rainfall and MPN at station #17 appears to indicate that rainfall may have been a large contributor to the total MPN variation.

d) Highest MPN counts in the study area occur between HW + 3.1 hours and HW + 6.2 hours. Flooding from station #2 and ebbing from station #10 into the Upper Bay at HW + 6.2 hours results in a chanelling effect of the MPN into the upper end of East Passage.

SECTION IV - EFFECTS OF HURRICANE BARRIERS ON WATER QUALITY

81. General The determination of the effects of the proposed hurricane barriers on water quality can be made using the results of the preceding analysis. These determinations are made only for dissolved oxygen and the most probable number of coliform bacteria which constitute the indicators of water quality conditions used in this study. The estimates of the effects of the barriers are for the period of the survey; hence, the estimates represent what the quality would have been during the 1959 survey had the barriers been in place. This is felt to be logical since the diverse conditions, which occurred in all factors during the survey, can be taken as being representative of a range of conditions which may be expected at the time the barriers are in operation. The only exceptions to this are the changes in conditions which occur throughout the year, which were not represented during the two month survey, and longer term changes, for example, from year to year or five year to five year variations. However, as has been discussed previously, these changes are due primarily to causes which undoubtedly will not be affected by the barriers. It is believed that the effects of the barriers will be during periods of time considerably shorter than a yearly cycle. It is assumed then, that the primary effects of the barriers on water quality will be due wholly to the changes imposed on the principal tidal regime of the Bay, eliminating the relatively smaller tidal components.

82. Methodology It was indicated in the previous section that, for dissolved oxygen and MPN, significant results were obtained by using the sinusoidal analysis indicating that the three cycles chosen do affect these variables in different degrees. It was also shown that, in general, the seasonal influence was not predominant although at some stations it did appear to be present. However, for both variables there remained residual variations which were not accounted for by the three cycles chosen. These residual variations are assumed to be due to causes which will not be affected by the barriers. In some instances possible explanations were offered as to the nature of these causes. Recognizing that this residual variation exists, an analysis of the sinusoidal relationships can be made to determine the effects of the barriers. The final concluding statements will then include the estimates plus the residual variations which remained. This is done so that care is exercised during the future time at which the barriers are in operation. A decrease in quality after the barriers are constructed may not be due to the structures at all but may be due to certain combinations of the residual variations, thereby leading to lowered quality levels.

83. As a preliminary step, scatter diagrams plotting the raw dissolved oxygen data against the tidal heights and tidal ranges at the time of sampling were made. These diagrams appeared to indicate a general trend of higher dissolved oxygen values and lower MPN values with higher stages of the tide. It appeared then that some relationship existed between the stages of the tide and the quality variables. With a statistically significant variation in either DO or MPN as a function of the time of tide, and with the variation of tidal height as a function of the time of tide, analyses can be made between the two variables (DO or MPN and tidal height) with time as the parameter. The changes imposed by the barriers on the tidal height variation can then be imposed on the relationship obtained and the subsequent change in dissolved oxygen or MPN can be determined.

84. It can be shown, (see Appendix B) that the relationship between two sine curves can be either a straight line one or an eliptical one depending on the phase angle relationships. Briefly, with the phase angles equal (e. g. maximum values of dissolved oxygen occur at maximum values of tidal height) the relationship is a straight line with the slope given by the ratio of the respective sinusoidal amplitudes. For phase angles which are 180° out of phase, (e. g. maximum values of MPN at minimum values of tidal height) the relationship is again a straight line with a negative slope given by the ratio of the amplitudes. For all other phase angle differences, the relationship between the two variables is eliptical where at a 90° or 270° phase angle difference, the major and minor axes are parallel to the original axes. At other phase angle differences, the elipse is at some angle with the original axes.

85. It should be remembered that the eliptical (or straight line) relationships which are determined represent the variation in dissolved oxygen (or MPN) with tidal height only. The effect of seasonal influences on the variation in dissolved oxygen and the residual variation in dissolved oxygen due to causes which will not be affected by the barriers still exist but have in essence been removed by utilizing only the tidal cycle variations. The sinusoidal variation of either dissolved oxygen or MPN across a tidal cycle (or lunar cycle) is thus viewed as the best estimate of the variation over this cycle with the remaining influences (seasonal and residual) at the mean value. It may be seen then, (and this will become clearer in the actual applications) that any changes in the tidal regime will alter only the quality variable within the limits determined by the tidal sinusoidal relationships provided that the tidal changes are within the variations presently existing in the Bay. Such is the case for the barrier plan under study. In other words, there will not be any need for extrapolation of values, but rather for interpolation of values.

There is no reason to assume for example, that by changing the level of high water from 4.0 feet to 3.0 feet that the dissolved oxygen will fall outside the range presently observed at 3.0 feet. Only if the barriers were to change the tidal regime beyond limits already existing for which no dissolved oxygen results have been observed would there be a need for extrapolation of the relationship obtained. In a sense then, the Bay acts as a laboratory in which conditions are met which will be met after the barriers are constructed.

86. The final point to be remembered is that the changes in quality which will result are related primarily to relatively short term cycles, the longest being the lunar cycle. Further, these cycles are due primarily to lunar astronomical conditions (eliminating solar tidal effects) which in turn do not affect other factors which may influence the dissolved oxygen or MPN. For example, it is assumed that the 12.42 hour tidal cycle relationship determined for dissolved oxygen is due solely to changes in the tidal regime and not to, for example, temperature changes which have been shown to be negligible over a tidal cycle.

87. Results of dissolved oxygen-tidal height analyses The results of the sinusoidal analysis discussed in Section III provide the limits within which changes in dissolved oxygen may occur as a result of the barriers. As shown in Section III and in Tables B-7 and B-8 of Appendix B, the estimated present variation in dissolved oxygen across a tidal cycle is relatively small although existant. These variations ranged from negligible to more than 1.0 ppm at some stations. In general, however, the relative magnitude of these variations is small compared to the total range of dissolved oxygen. The limits of dissolved oxygen across a tidal cycle represent the maximum effect that the barriers could have on the dissolved oxygen provided that the changes in the tidal regime occasioned by the barriers are within the changes presently experienced.

88. The dissolved oxygen sinusoidal relationships which were discussed in Section III were used together with the sinusoidal relationship for the tidal height with the time of tide as the parameter. Some typical results are shown in Figure 32 together with the estimated changes occasioned by the barriers proposed under Plan 35. The changes in tidal heights which may result from the barriers were determined from the results of model studies performed by the Corps of Engineers at Vicksburg, Mississippi.12/ Since the ranges in tidal height which occurred during the survey were not exactly the same as the ranges in tidal height used in the model studies, a direct proportion between the two was used.

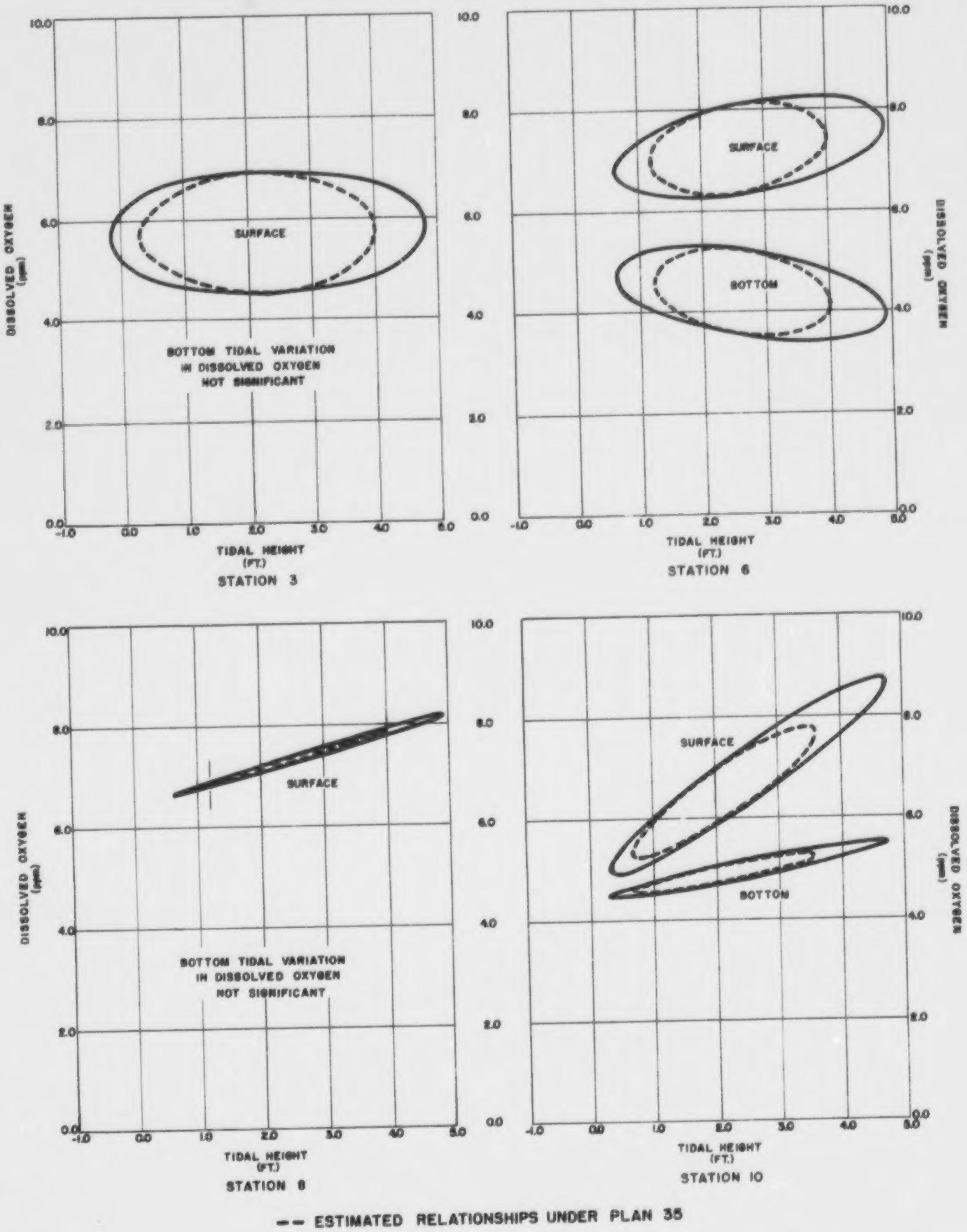
89. Inspection of Figure 32 indicates that the effects of the barriers will be quite small. In general, for those stations at which the dissolved oxygen and the tidal height are 180° out of phase, the effects of the barriers are the largest, and when the two variables are either 90° or 270° out of phase, the effects of the barriers is the smallest. Where the barriers do affect the dissolved oxygen at a particular station, the effect consists mainly of reducing the dissolved oxygen at high tide and increasing the dissolved oxygen at low tide, but not by the same amount. Hence, in order to preserve the sinusoidal relationship, the average across the tidal cycle must change. If the dissolved oxygen amplitude above the present mean is decreased more than the amplitude below the mean is increased, then the mean must decrease in order to keep both amplitudes at the same value. It can also be seen that if maximum or minimum conditions occur at the time when the tidal height curve is passing through its mean, then changes in tidal height will have little effect on the dissolved oxygen.

90. The relationships between dissolved oxygen and tidal height were determined for each station and depth except at those locations where the statistical analyses indicated that the variation in dissolved oxygen across a tidal cycle was non-significant. These relationships were made under mean tidal conditions, and variations can occur due to changes during the lunar cycle. However, these changes are in the same direction as those changes estimated for mean tidal conditions.

91. Using the results of these determinations, new dissolved oxygen isopleths at HW + 0.0 hours and HW + 6.2 hours have been plotted in Figures 33 and 34. These figures can be compared with Figures 16 surface and 18 surface, which indicated the dissolved oxygen under present conditions. The isopleths for the bottom dissolved oxygen are not plotted sinc the change is estimated to be extremely small. Figures 33 and 34 indicate that at HW + 0.0 hours, the general effect of the barriers is to increase the dissolved oxygen in the eastern half of the Upper Bay as well as in Mount Hope Bay in the vicinity of station #19. Little to no change occurs elsewhere in the study area.

92. At HW + 6.2 hours, it can be seen that dissolved oxygen conditions improve somewhat although not to the same degree that conditions were impaired at HW + 0.0 hours. Again, little change occurs outside of the eastern end of Upper Narragansett and Mount Hope Bays.

93. Conclusions In general, the barriers will have little effect on the dissolved oxygen resources of the study area. Average dissolved



EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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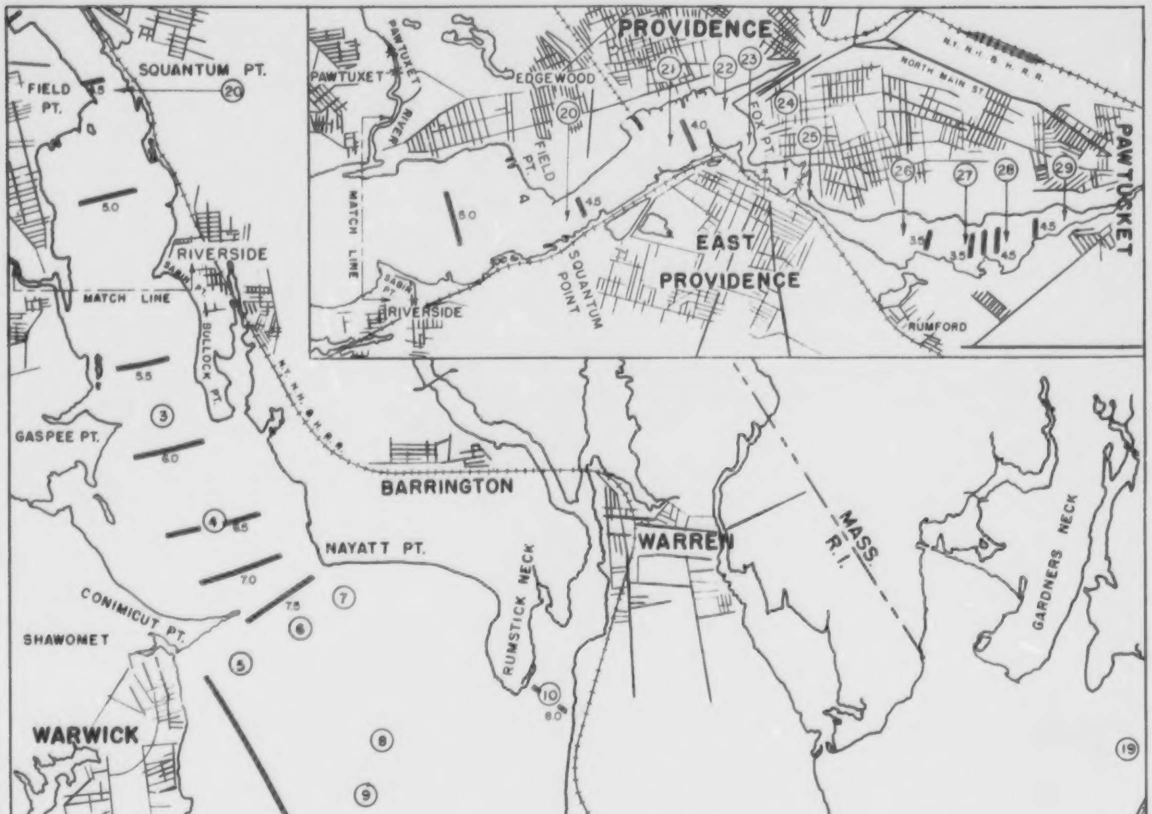
FIGURE 32
SEVERAL RELATIONSHIPS
DISSOLVED OXYGEN vs. TIDAL HEIGHT AT
AVERAGE LUNAR MONTHLY CONDITIONS


PROVIDENCE
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PAWTUCKET
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POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
SCALE IN FEET
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7.5
8.0

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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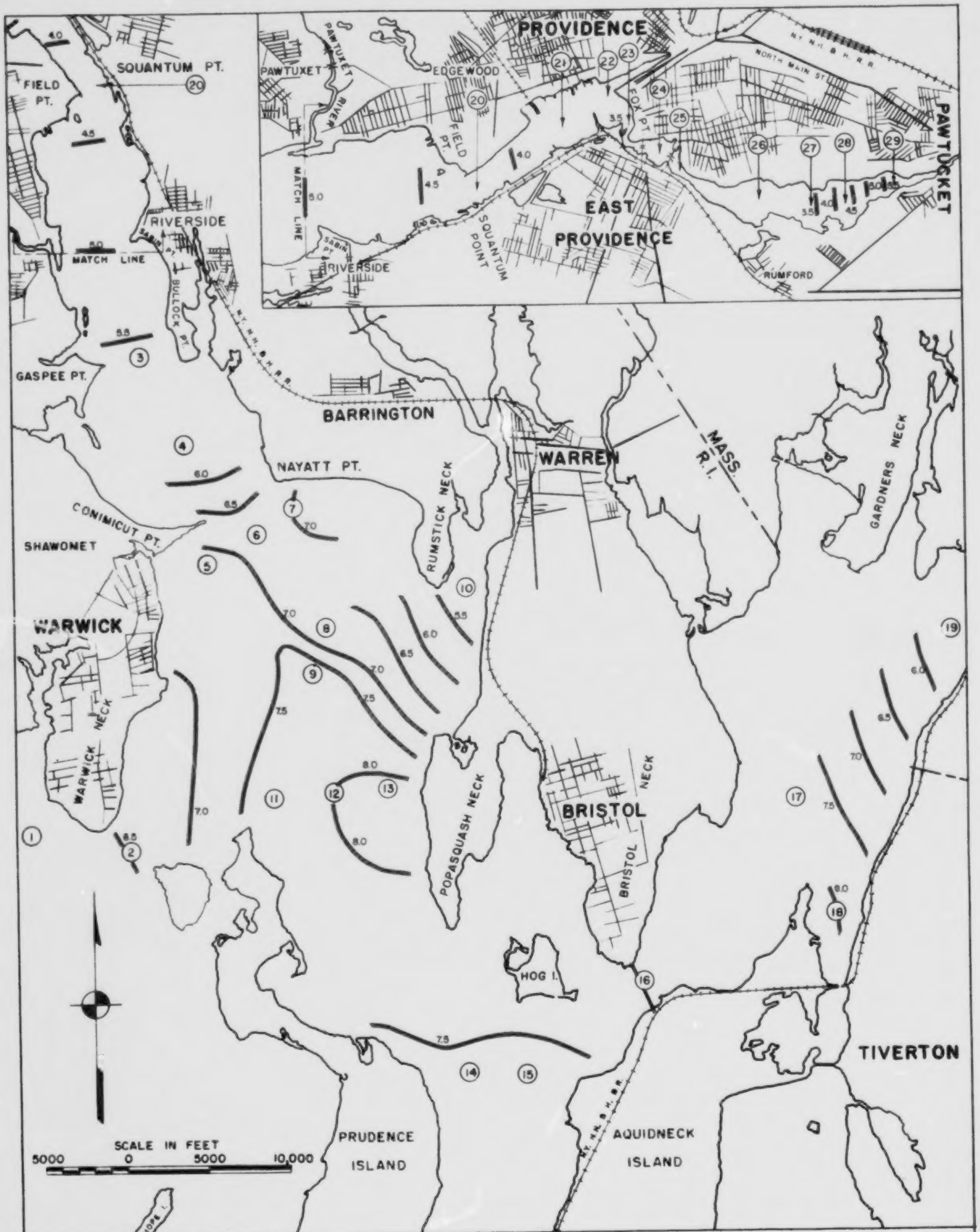
FIGURE 33
ESTIMATED DISSOLVED OXYGEN ISOPLETHS (ppm)
AT HIGH WATER + 0.0 HOURS UNDER PLAN 35
SURFACE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POPASQUASH NECK
BRISTOL
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TIVERTON
PRUDENCE ISLAND
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HOPE I.
SCALE IN FEET
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EFFECTS OF PROPOSED HURRICANE BARRIERS ON WATER QUALITY OF NARRAGANSETT BAY

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FIGURE 34
ESTIMATED DISSOLVED OXYGEN ISOPLETHS (ppm) AT HIGH WATER + 6.2 HOURS UNDER PLAN 35
SURFACE

oxygen across a tidal cycle will decrease slightly and in some cases the barriers will have no effect on the dissolved oxygen. During the various phases of the tide, the barriers will tend to lower the maximum dissolved oxygen levels while raising the minimum dissolved oxygen levels, but not by the same amount. Hence, the degree of vertical stratification will increase, since the variation during the phases of the tide will decrease. This presents a complex situation consisting of the effects of a decrease in the mean dissolved oxygen across a tidal cycle being balanced to some extent by a decrease in the range of dissolved oxygen. Increased vertical stratification in the case of dissolved oxygen could be viewed as beneficial, since the surface dissolved oxygen will no longer drop to as low a level after the barriers as before the barriers. Since the major effect on vertical stratification consists of a decrease in the surface dissolved oxygen variations, low dissolved oxygen values at certain stages of the tide will be prevented although the mean dissolved oxygen will be decreased. It is not believed that for the changes estimated to occur as a result of the barriers that the effects will be pronounced. Indeed, with the small changes estimated, it is doubtful if they could be measured after the barriers are constructed. In other words, the change appears to be of an order of magnitude that the effects of other causes may mask their determination.

94. Results of MPN - tidal height analyses In order to estimate the effects of the proposed barriers on the MPN count, the same procedure used in the estimation of changes in dissolved oxygen has been applied. As discussed previously, the sinusoidal analysis indicated that in general the variation in MPN during a tidal cycle, although present, represents a relatively small portion of the total observations. The range in MPN over a tidal cycle represents the maximum change that the barriers could impose on the MPN provided that the changes in the tidal regime are within those presently observed.

95. Figure 35 presents some typical results from the analysis of MPN and tidal height. The estimated MPN-tidal height relationship with the barriers (as proposed under Plan 35) in place was determined in part from the changes in tidal height resulting from model studies.[12] The MPN-tidal height analysis was made on all stations and depths for which a significant tidal variation was determined from the sinusoidal analysis. The plots indicated in Figure 35 are for mean lunar conditions and variations from those plots can occur during the different times of the lunar

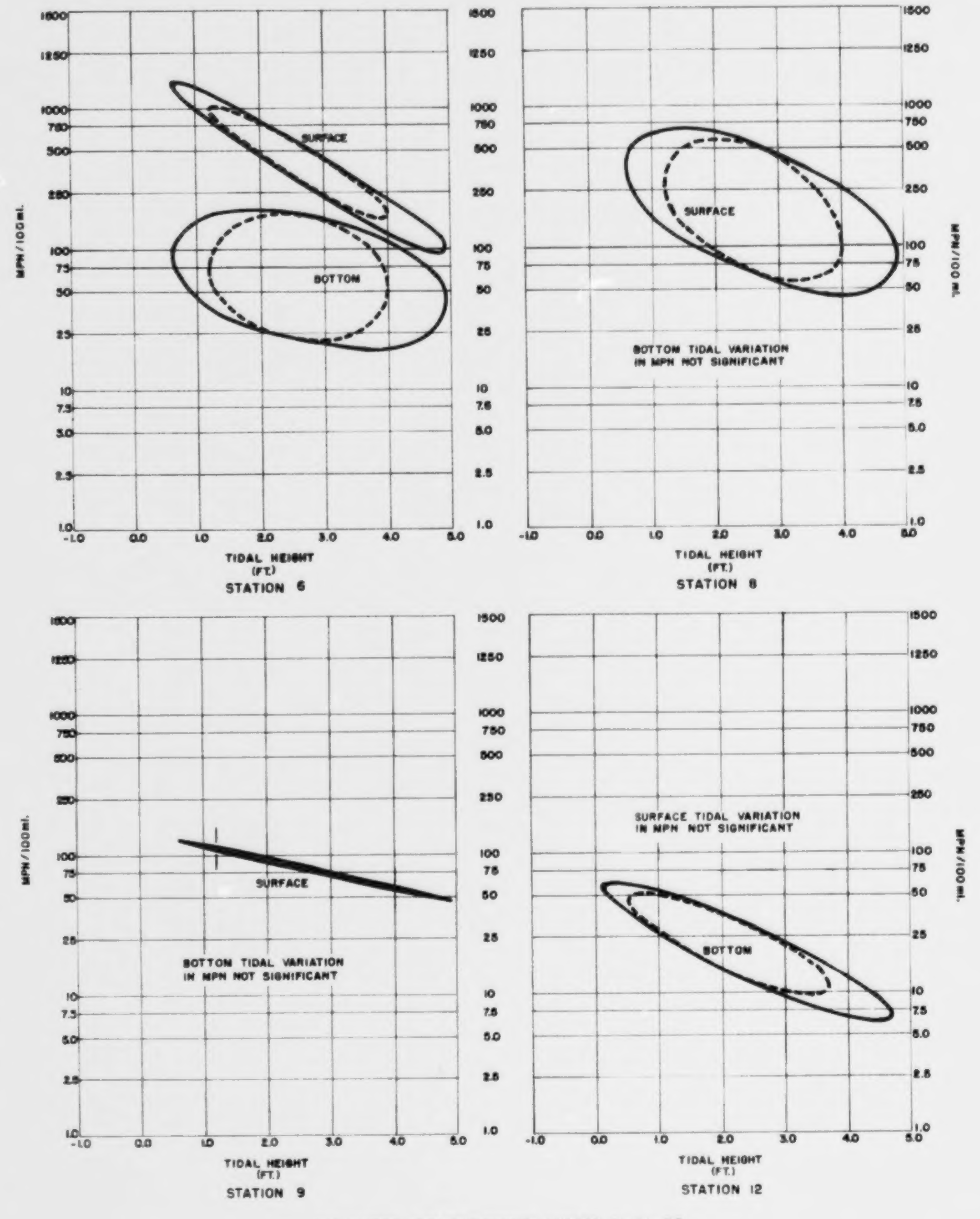
month. An indication of these variations can be obtained by inspecting Tables B-9 and B-10. The direction of change in the MPN due to the barriers will remain the same at the various stages of the lunar month.

96. As with the dissolved oxygen, it is seen that for any given station, the change in average MPN over a tidal cycle is relatively small although significant changes do occur at the times of high and low water. The greatest change occurs where the MPN and tidal height are 180° out of phase (i. e. maximum MPN at minimum height and vice versa) as can be seen in station #12, surface. For those stations at which the barriers affect the MPN, the effect consists of raising the MPN at high tide and lowering the MPN at low tide.

97. Figures 36 and 37 present the MPN ranges estimated to occur in the study area with the Plan 35 barriers in place. As was indicated in paragraph 89, there will be little change in quality at the peak current times. Figures 36 and 37 can be compared with Figures 28 and 30 in order to estimate the changes in MPN. At HW + 0.0 hours, on the surface, the effects of the Plan 35 barriers on the MPN is concentrated mainly in Upper Narragansett Bay south of station #6. As seen in Figure 36, surface, as opposed to Figure 28, surface, the 100-1000 MPN range reaches into the Upper Bay and joins the 100-1000 MPN range at the entrance to the Warren River. Also, a slight southern shift in this same range in Mount Hope Bay can also be noted. For the bottom waters at the same stage of the tide the effect of the barriers is felt primarily at the upper end of East Passage (stations #11, 12 and 13) where the range increases from less than 10 MPN to 10-100 MPN. No change in the bottom MPN range is observed elsewhere in the study area. Both the surface and bottom changes in MPN estimated to result from the Plan 35 barriers reflect the decreased flooding current due to the barrier constrictions.

98. In comparing Figure 37 with Figure 30, it is seen that the decreased ebb current resulting from the barriers results in an improvement in the MPN. This is probably due to the decreased longitudinal movement of high MPN waters into waters of lower MPN. Also, the flooding effects from stations #2 and #10 into the Upper Bay area becomes relatively stronger, thereby decreasing the overall MPN range in this area. It can be noted that little change is expected to occur in the bottom MPN values.

99. Conclusions The net effect in the MPN count during a tidal cycle (and also in a lunar cycle) resulting from the barriers under Plan 35



EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

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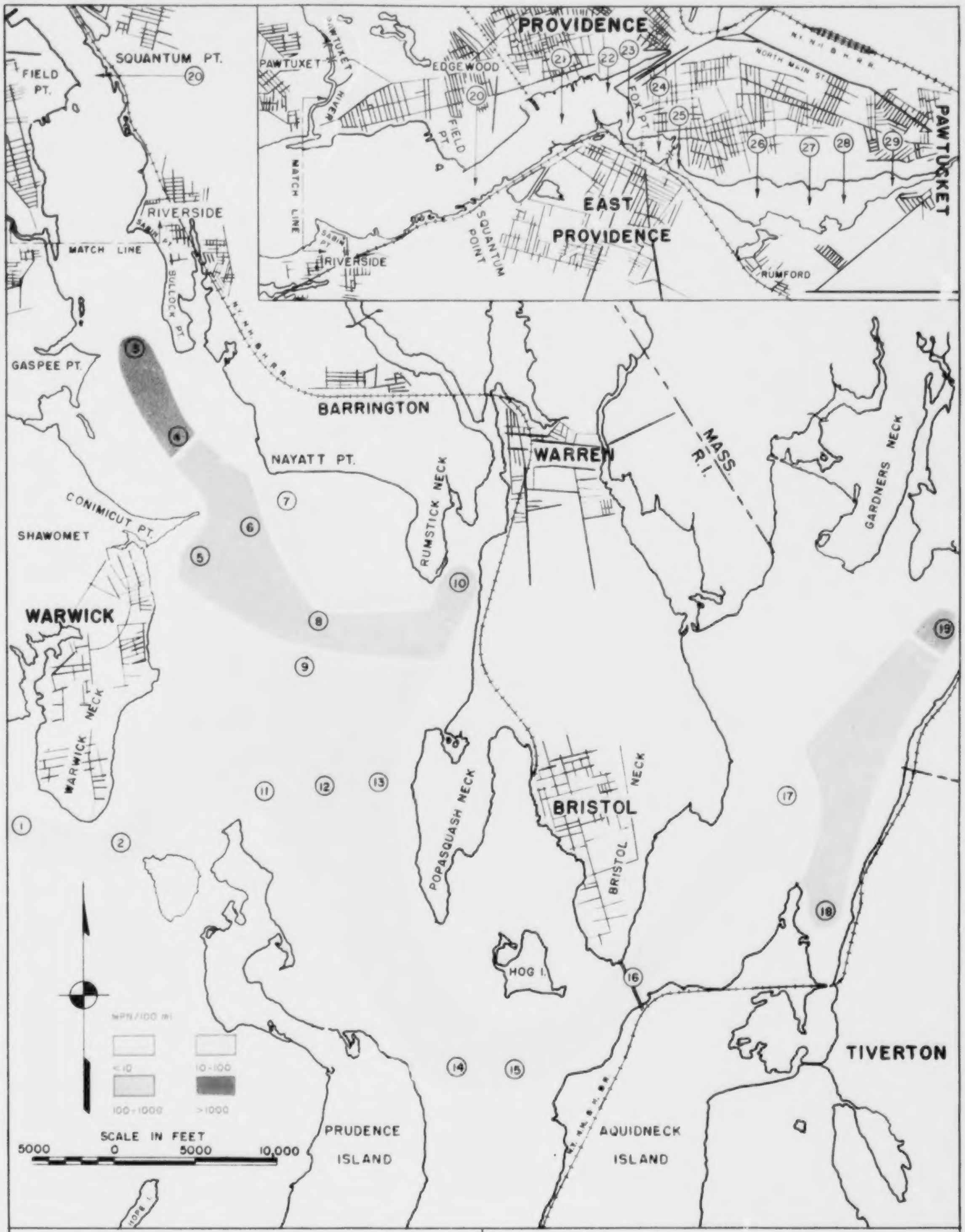
FIGURE 35
SEVERAL RELATIONSHIPS
MPN vs. TIDAL HEIGHT AT
AVERAGE LUNAR MONTHLY CONDITIONS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NORTH MAIN ST.
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SQUANTUM PT.
FIELD PT.
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
MPN/100 ml
<10
10-100
100-1000
>1000
SCALE IN FEET
5000
0
5000
10,000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
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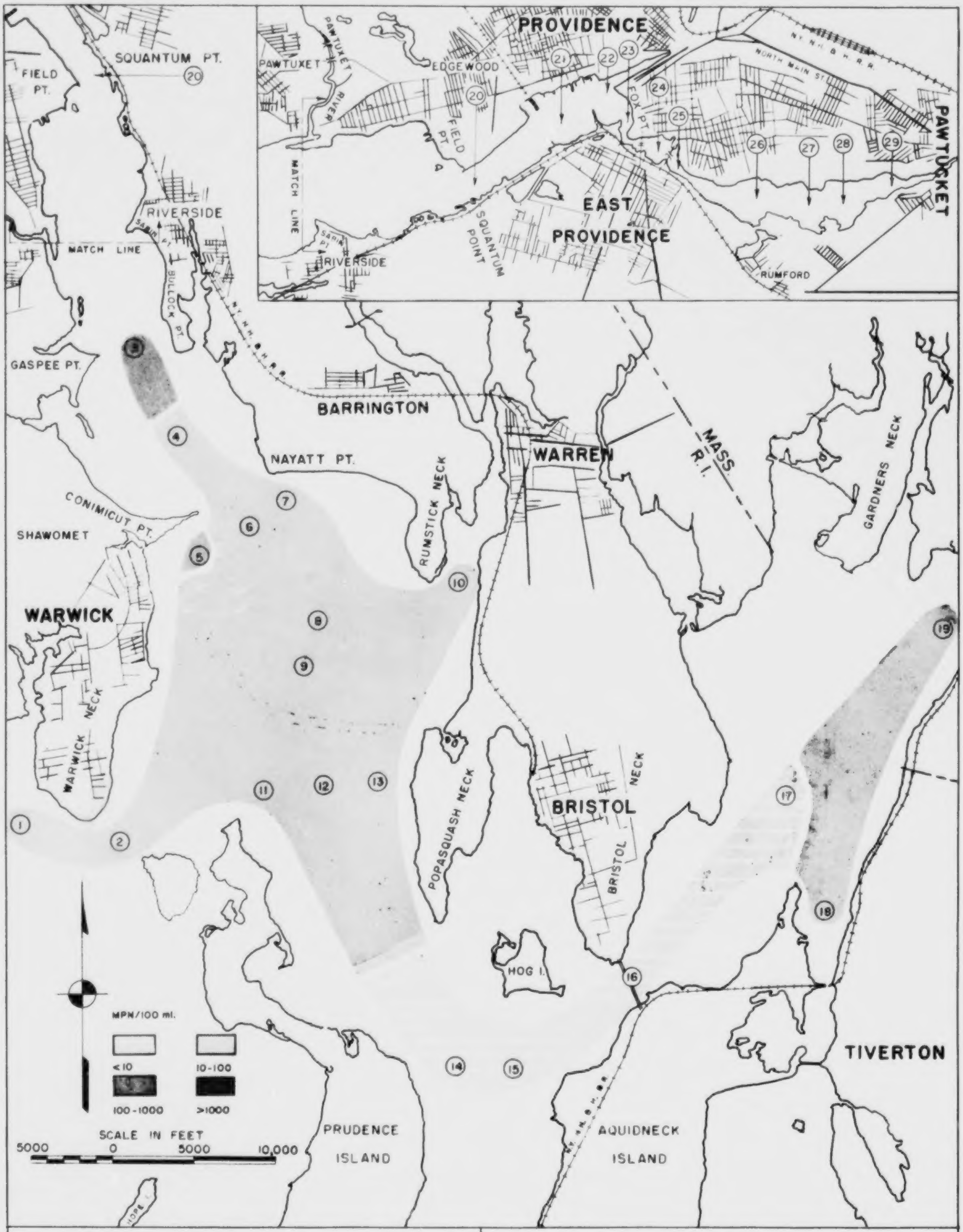
27
28
29

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

U.S. DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

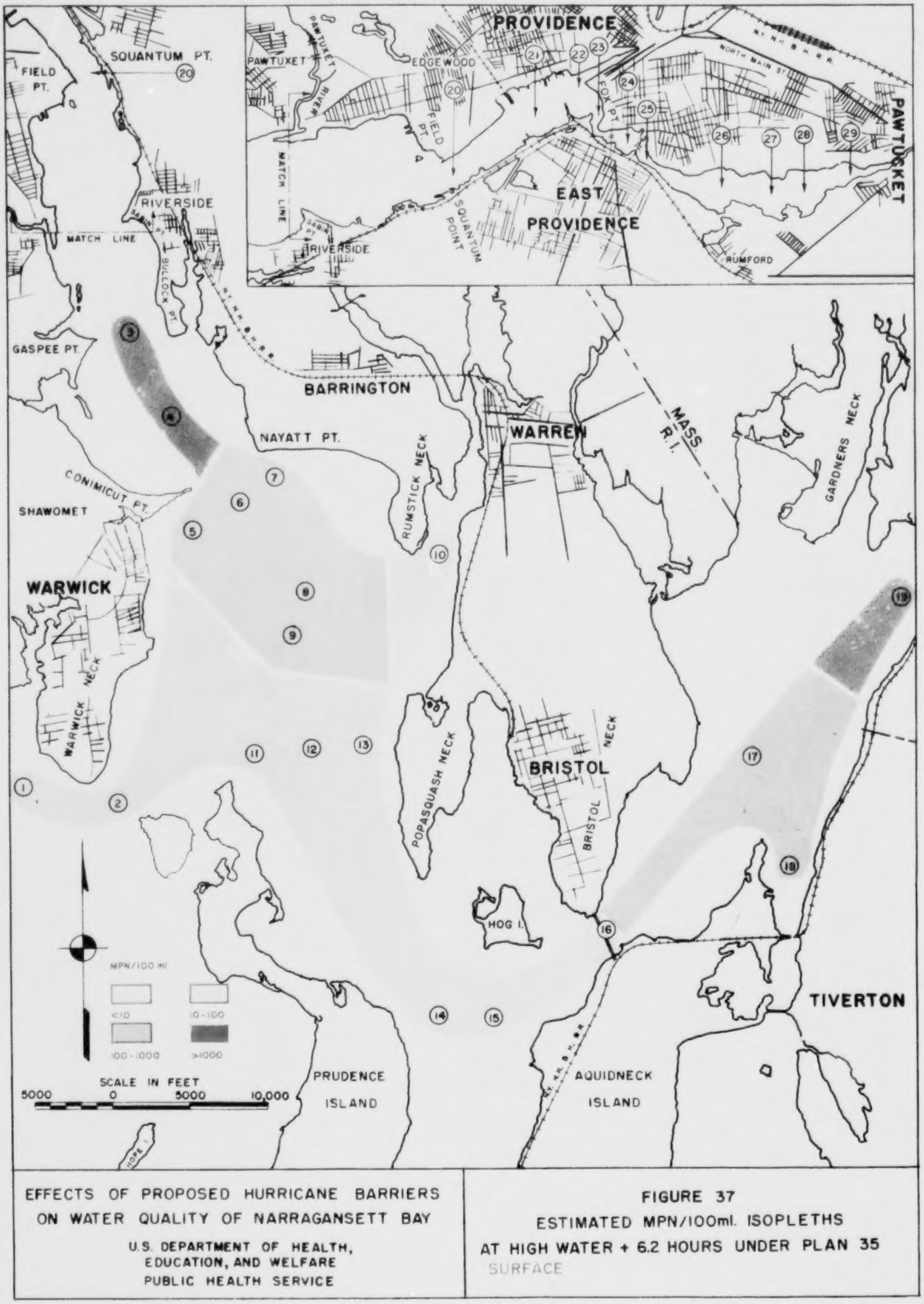
FIGURE 36
ESTIMATED MPN/100ml. ISOPLETHS
AT HIGH WATER + 0.0 HOURS UNDER PLAN 35
SURFACE


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT.
FOX PT.
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
PAWTUCKET
EAST PROVIDENCE
SQUANTUM POINT
RIVERSIDE
SABIN PT.
MATCH LINE
RUMFORD
20
21
22
23
24
25
26
27
28
29
FIELD PT.
SQUANTUM PT.
RIVERSIDE
SABIN PT.
BULLOCK PT.
MATCH LINE
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
RUMSTICK NECK
WARREN
MASS
R.I.
GARDNERS NECK
WARWICK
WARWICK NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
MPN/100 ml.
<10
10-100
100-1000
>1000
SCALE IN FEET
5000
0
5000
10,000

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

U.S. DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

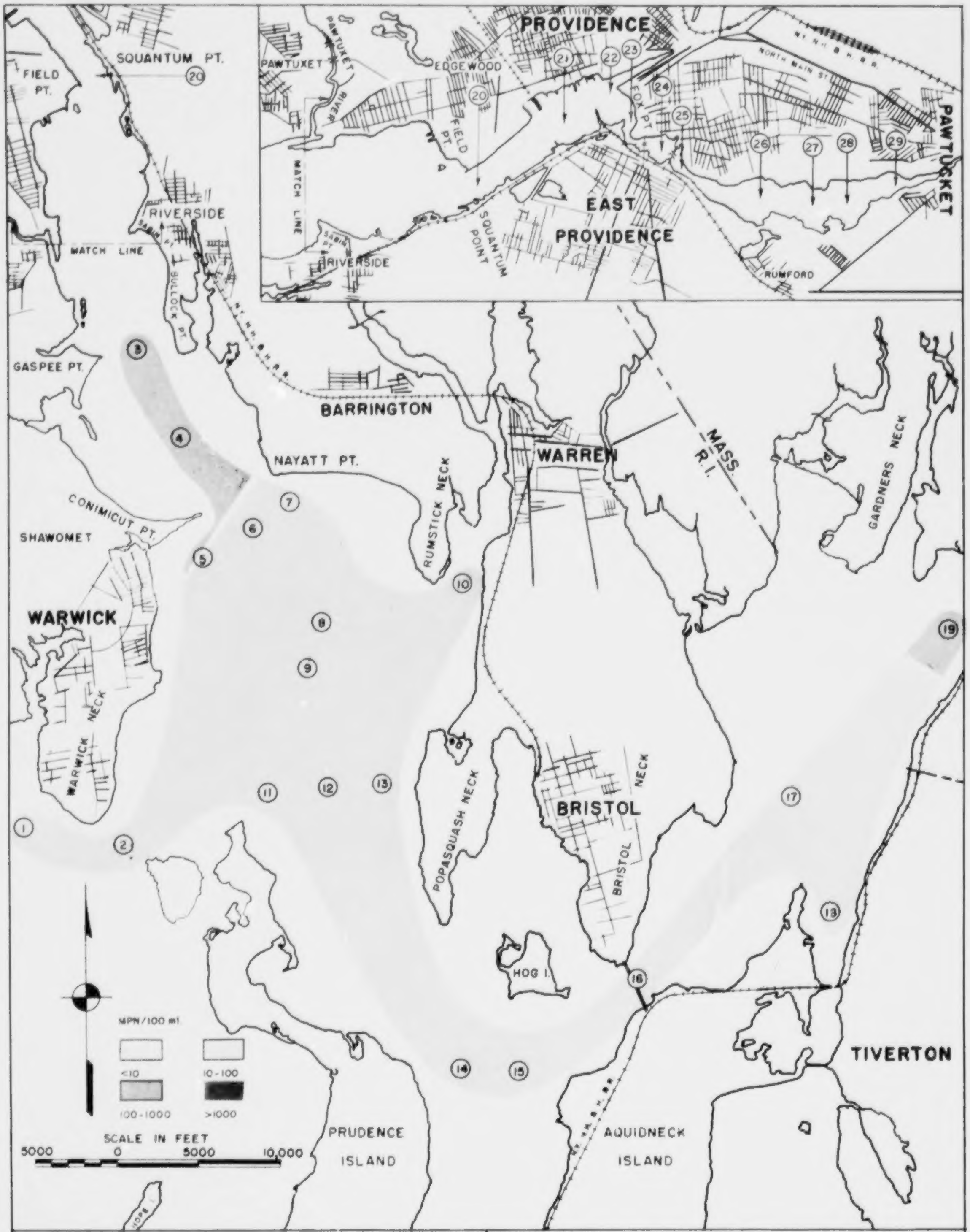
FIGURE 36
ESTIMATED MPN/100ml. ISOPLETHS
AT HIGH WATER + 0.0 HOURS UNDER PLAN 35
BOTTOM


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT
MATCH LINE
N 4
FOX PT.
NORTH MAIN ST.
N.Y. N.H. & H. R.R.
PAWTUCKET
EAST PROVIDENCE
SQUANTUM POINT
SABIN PT.
RIVERSIDE
RUMFORD
20
21
22
23
24
25
26
27
28
29
SQUANTUM PT.
FIELD PT.
RIVERSIDE
SABIN PT.
MATCH LINE
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS
R.I.
GARDNERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
MPN/100 ml
<10
10-100
100-1000
>1000
SCALE IN FEET
5000
0
5000
10,000

EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

U.S. DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

FIGURE 37
ESTIMATED MPN/100ml. ISOPLETHS
AT HIGH WATER + 6.2 HOURS UNDER PLAN 35
SURFACE


PROVIDENCE
PAWTUXET
PAWTUXET RIVER
EDGEWOOD
FIELD PT
FOX PT
NORTH MAIN ST
N.Y.N.H. & H.R.R.
PAWTUCKET
MATCH LINE
SABIN PT
RIVERSIDE
SQUANTUM POINT
EAST PROVIDENCE
RUMFORD
SQUANTUM PT.
FIELD PT.
MATCH LINE
BULLOCK PT.
GASPEE PT.
BARRINGTON
NAYATT PT.
CONIMICUT PT.
SHAWOMET
WARWICK
WARWICK NECK
RUMSTICK NECK
WARREN
MASS.
R.I.
GARDINERS NECK
POPASQUASH NECK
BRISTOL
BRISTOL NECK
HOG I.
TIVERTON
PRUDENCE ISLAND
AQUIDNECK ISLAND
HOPE I.
MPN/100 ml.
<10
10-100
100-1000
>1000
SCALE IN FEET
5000
0
5000
10,000
1
2
3
4
5
6
7
8
9
10
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EFFECTS OF PROPOSED HURRICANE BARRIERS
ON WATER QUALITY OF NARRAGANSETT BAY

U.S. DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

FIGURE 37
ESTIMATED MPN/100ml. ISOPLETHS
AT HIGH WATER + 6.2 HOURS UNDER PLAN 35
BOTTOM

is expected to be small. In general, at those stations where the MPN is measurably affected by the tide, the effects of the barriers will be to increase the MPN at high water and decrease the MPN at low water. Essentially, this results in decreased vertical mixing (increased vertical stratification) during the different stages of the tide. From an area-wide point of view, the most critical location appears to be at the entrance of the Providence River into the Upper Bay where the change in flood current results in insufficient longitudinal current velocity to "push" Upper Bay water into the Providence. On the other hand, the reduced ebb current velocity results in a "holding-back" of high MPN waters in the Providence River. This is coupled with a relative increase in the flooding effect from the West Passage and the Warren River into the Upper Bay area. At high water, then, the MPN count is estimated to increase in the northern end of the Upper Bay. At low water the southern end of the Upper Bay will benefit where a decrease in MPN is expected.

100. As with the estimated dissolved oxygen changes, it is not believed that the changes estimated to occur in the MPN will result in pronounced effects. Since the greatest portion of the total MPN variation is due to causes which are not assumed to be affected by the barriers, the determination of these small changes after the barriers are constructed would be extremely difficult.

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APPENDIX A

RESULTS OF 1959 SURVEY

EXPLANATION OF COLUMNS

Column (1)	The time of year in days starting with January 1 as the first day. Day 173 is June 22.
Column (2)	The time of day in hours at which the sample was collected based on a 24 hour clock. All times are Eastern Standard time.
Column (3)	The time of the last high tide in hours prior to the time at which the sample was collected. If this time is greater than the time shown in column (2) this indicates that the time of last high tide occurred on the day previous to the day during which the sample was collected. All times are Eastern Standard time.
Column (4)	The Most Probable Number of coliform organisms per 100 ml.
Column (5)	Water temperature in degrees Centigrade.
Column (6)	The specific conductance in micromhos.
Column (7)	The dissolved oxygen in parts per million.
Column (8)	The 5-day, 20°C. biochemical oxygen demand in parts per million.

STATION 1 TOP

TIME OF YEAR (DAYS) (1)	DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0714	2025	7	16.5	43,600	7.2	1.1
175	0810	2200	9	19.5	41,700	11.4	7.2
176	0755	2310	23	17.5	42,300	7.5	2.0
177	0758	2350	9	18.5	42,763	6.6	2.0
180	0722	0230	4	19.0	30,000	7.5	2.9
181	0707	0310	7	22.5	41,620	8.2	
182	0711	0410	9	18.5	43,913		4.0
183	0735	0500	750	20.0	40,910	8.9	4.3
184	0721	0515	2,400	19.0	43,083	7.3	3.4
187	0803	0700	2	20.5	41,390	6.3	1.6
188	0706	1930	460	20.0	42,700	6.3	
189	0705	2030	13	19.0	43,470	6.2	
190	0708	2100	9	21.0	42,241	6.9	1.9
191	0713	2120	4	21.0	43,593	6.2	
194	1300	1230	110	22.0	41,624	7.2	
195	1253	0100	49	21.0	43,290		
197	1254	0345		21.0	38,920		3.4
198	0703	0420		19.5	39,234	6.7	
198	0703	0420		19.5		6.7	
201	0709	0700	15	21.0	43,244	6.0	
202	0703	1940	43	21.0	42,121	5.5	
203	0724	2045	23	22.5	41,760	6.6	
204	0710	2130	23	22.5	41,404	6.0	
205	0710	2210	23	24.0	40,373	6.0	
206	0712	2300	75	21.0	39,795	6.3	
209	0821	0120	43	23.5	42,121	7.2	
210	0710	0240	23	22.0	41,760	7.5	
211	0712	0350	7	22.5	40,420	6.8	2.2
214	0707	0600	43	19.0	41,110	5.5	
215	0711	0610	9	20.5	38,720	6.1	
217	0705	2020	9	18.0	43,410	5.4	
218	1116	0940	2	20.0	42,271	6.2	1.6
219	1651	1010	43	20.5	40,844	8.1	4.2
222	0804		23	19.5	39,190	4.8	
223	0700	0120	4	20.5	41,905	6.0	
224	0709	0145	240	20.0	41.545	5.9	
225	0710	0250	43	21.0	42,271	6.2	

STATION 1 BOTTOM

TIME OF YEAR (DAYS) (1)	DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0727	2025	2	16.5	43,050	6.8	.8
175	0813	2200	23	18.5	43,990	6.8	.6
176	0755	2310	2	17.0	43,733	7.1	.9
177	0758	2350	4	17.5	43,640	6.2	.9
180	0722	0230	4	17.5	44,320	4.2	.5
181	0707	0310	7	20.5	44,820	5.9	
182	0711	0410	4	17.0	43,070	4.2	1.8
183	0735	0500	230	19.0	43,490	2.4	
184	0721	0515	930	17.5	44,042	4.6	3.0
187	0803	0700	2	19.5	43,280	5.9	1.0
188	0706	1930	4	19.0	43,800	5.4	
189	0705	2030	2	18.0	43,661	5.2	
190	0708	2100	4	19.5	44,580	5.0	1.6
190	0708	2100	4	19.5			
191	0713	2120	4	20.0	44,174	5.8	
194	1300	1230	110	21.0	43,680	4.8	
195	1253	0100	21	20.0	44,072	4.9	
197	1254	0345		20.0	44,230	3.6	.1
198	0703	0420	460	18.5	44,030	3.6	
201	0709	0700	23	20.5	39,780	5.6	
201	0709	0700	23	20.5		5.6	
202	0703	1940	93	21.0	42,490	5.0	
203	0724	2045	23	21.0	43,244	4.7	
204	0710	2130	43	21.5	42,400	4.2	
205	0710	2210	9	22.5	42,490	4.0	
206	0712	2300	7	20.5	41,940	4.1	
209	0821	0120	23	21.0	44,030	2.1	
210	0710	0240	93	21.0	43,244	1.8	
211	0712	0350	4	21.0	43,111	2.0	1.2
214	0707	0600	26	19.0	42,460	4.1	
215	0711	0610	15	18.0	44,000	2.3	
217	0705	2020	9	18.0	44,000	3.8	
218	1116	0940	2	19.0	42,271	4.9	.8
219	1651	1010	9	19.5	43,214	5.3	.9
222	0804		4	19.0	43,801	4.1	
223	0700	0120	2	20.0	43,410	3.7	
224	0709	0145	9	19.0	43,604	3.5	
225	0710	0250	7	20.0	44,000	3.5	

STATION 2 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0727	2025	23	16.0	45,800	6.8	.7
175	0822	2200	2	18.0	43,680	8.3	2.5
176	0807	2310	43	16.5	43,250	7.9	2.6
177	0811	2350	23	17.5	42,680	7.5	2.2
180	0734	0230	4	17.5	44,120	6.7	2.1
181	0720	0310	43	20.5	42,140		
182	0722	0410	430	18.5	40,750	8.1	2.9
183	0747	0500	93	19.0	42,420	8.4	3.0
184	0738	0515	2,400	18.0	42,333	7.5	3.6
187	0813	0700	43	20.5	44,227	6.2	1.1
188	0717	1930	15	19.0	44,250	5.9	
189	0716	2030	75	19.0	43,740	5.9	
190	0720	2100	230	19.0	43,600	7.0	1.4
191	0724	2120	4	20.0	44,125	7.3	
194	1248	1230	49	22.0	44,072	8.1	
195	1242	0100	49	20.5	44,072	6.4	
196	0932	2133		22.0		5.1	
197	1241	0345		20.0	41,230	5.2	1.2
198	0714	0420	460	19.0	42,400	5.8	
198	0714	0420	1,100	19.0		5.8	
201	0721	0700	93	20.5	43,830	5.7	
202	0714	1940	9	21.0	43,053	5.5	
203	0735	2045	240	21.5	44,030	6.0	
204	0721	2130	93	22.0	42,212	5.5	
205	0721	2210	43	22.8	41,055	6.5	
206	0724	2300	9	21.0	41,760	5.8	
209	0833	0120	23	21.5	40,542	7.5	
210	0721	0240	93	21.5	41,230	7.5	
211	0724	0350	75	22.0	39,592	7.6	2.2
214	0718	0600	240	19.0	40,333	6.5	
215	0722	0610	1,100	18.0	41,545	6.1	
217	0715	2020	9	19.0	42,456	7.6	
218	1126	0940	43	19.5	42,090	7.0	2.0
219	1640	1010	93	20.0	43,022	7.3	2.2
222	0817		4	19.0	43,022	4.9	
223	0710	0120	39	19.0	43,022	5.3	
224	0715	0145		20.0	43,801	5.0	
225	0716	0250	23	20.0	44,404	5.0	

STATION 2 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0730	2025	2	16.0	45,400	7.1	.7
175	0822	2200	15	17.5	43,730	7.8	1.0
176	0807	2310	230	16.5	44,230	7.6	1.4
177	0811	2350	3	17.0	44,670	7.0	1.0
180	0734	0230	2	16.5	44,950	4.9	.2
181	0720	0310	4	18.5	41,561		
182	0722	0410	93	16.5	45,800	4.5	.5
183	0747	0500	75	17.5	44,100	4.9	.4
184	0738	0515	430	17.0	44,383	4.8	.7
187	0813	0700	20	19.5	44,862	6.2	1.0
188	0717	1930	4	18.5	44,250	6.1	
189	0716	2030	2	17.5	44,320	5.6	
190	0720	2100	4	19.0	43,840	5.6	.9
191	0724	2120	2	19.5	43,480	5.4	
194	1248	1230	110	21.0	44,273	5.9	
195	1242	0100	8	20.0	44,273	5.0	
197	1241	0345		19.0	44,030	4.0	.3
198	0714	0420	1,100	18.0	44,230	4.0	
201	0721	0700	23	20.5	43,053	5.8	
201	0721	0700	9	20.5		5.8	
202	0714	1940	9	20.5	43,053	5.4	
203	0735	2045	9	21.0	42,121	6.0	
204	0721	2130	15	21.0	42,675	5.0	
205	0721	2210	9	22.1	53,053	4.5	
206	0724	2300	23	20.0	42,304	4.6	
206	0724	2300	15	20.0		4.6	
209	0833	0120	23	20.0	43,244	2.3	
210	0721	0240	75	20.0	42,592	3.0	
211	0724	0350	9	23.3	43,891	1.3	1.0
214	0718	0600	15	18.0	43,801	3.1	
215	0722	0610	9	14.0	44,000	4.4	
217	0715	2020	23	18.5	43,604	4.9	
218	1126	0940	2	18.5	42,643	4.8	1.2
219	1640	1010	14	18.5	43,801	4.8	.6
222	0817		9	18.5	44,000	4.6	
223	0710	0120	43	18.5	42,460	4.4	
224	0715	0145	14	19.0	44,000	3.8	
225	0716	0250	15	19.0	44,000	3.8	

STATION 3 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0810	2020	300	17.5	44,600	4.9	1.9
175	0908	2215	2,400	20.5	39,160	4.9	2.5
177	0905	2346	4,600	19.0	36,440	3.4	1.7
180	0818	0230	430	19.0	37,500	3.5	1.4
181	0807	0320	1,500	23.0	33,280	5.3	
182	0808	0445	110,000	18.5	37,600	3.7	2.6
183	0838	0510	750	20.0	37,120	10.1	6.6
184	0820	0550	110,000	20.0	36,460	5.6	2.9
187	0855	0800	73	22.5	41,780	9.4	3.5
188	0758	2050	230	20.5	39,630	8.4	
189	0755	2130	24,000	21.5	36,245	5.8	
190	0800	2120	280	21.5	41,004	7.0	3.9
191	0803	2330	2,300	22.0	40,920	7.4	
194	1200	0120	345	24.5	33,450	11.2	
195	1155	0120	1,500	22.0	31,440	8.2	
197	1157	0400		20.0	31,800	3.0	1.4
198	0803	0520	24,000	21.0	34,874	1.4	
198	0803	0520	4,600	21.0		1.4	
201	0803	2000	46,000	23.0	32,542	4.8	
202	0753	2030	930	23.0	33,322	6.3	
203	0812	2140	75	24.0	29,220	5.8	
204	0800	2240	46,000	24.5	24,386	5.8	
205	0800		750	24.1	24,885	6.9	
206	0810	2330	46,000	21.5	23,703	6.6	
209	0913	0220	4,300	24.0	32,112	10.4	
210	0805	0300	2,400	22.5	33,540	9.8	
211	0810	0410	930	25.0	30,892	10.9	7.0
214	0805	0540	4,600	20.0	35,460	4.5	
215	0807	0640	11,000	19.5	37,812	5.2	
217	0754	2000	9,300	19.5	40,250	6.1	
218	1212	0900	2	20.5	37,961	3.8	3.0
219	1557	0930	9,300	20.0	40,672	4.2	1.4
222	0845	0010	4,300	19.5	39,350	4.2	
223	0746	0100	2,300	20.5	41,191	2.8	
224	0750	0200	2,300	20.0	41,905	2.0	
225	0750	0310	4,300	22.0	40,166	3.0	

STATION 3 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0816	2020	360	16.0	44,900	5.6	.6
175	0908	2215	93	18.5	43,380	5.9	.8
176	0858	2315	23	16.0	42,710	4.7	.3
177	0905	2346	240	17.0	43,070	4.9	1.1
180	0818	0230	23	17.0	44,320	4.3	.4
181	0807	0320	43	19.5	44,234	3.8	
182	0808	0445	1,500	16.0	44,460	4.3	.7
183	0838	0510	1,500	17.0	44,180	3.7	.9
184	0820	0550	460	17.0	44,980	4.0	.1
187	0855	0800	430	19.5	44,977	2.4	.8
188	0758	2050	43	17.5	44,720	2.8	
189	0755	2130	430	19.0	43,800	4.2	
190	0800	2120	39	19.0	45,270	3.6	.9
190	0800	2120	750	19.0			
191	0803	2330	93	19.0	44,181	2.7	
194	1200	0120	93	20.0	42,533	3.8	
195	1155	0120	460	19.0	43,874	3.7	
197	1157	0400	2,400	18.5	43,632	3.4	.3
198	0803	0520	2,400	19.0	43,244	3.0	
201	0803	2000	230	21.0	42,121	4.2	
201	0803	2000	230	21.0		4.2	
202	0753	2030	430	20.0	42,121	4.0	
203	0812	2140	240	21.0	42,490	3.9	
204	0800	2240	460	21.0	31,360	3.8	
205	0800		460	20.5	41,581	3.6	
206	0810	2330	400	18.5	42,121	3.3	
209	0913	0220	390	19.5	43,830	3.1	
210	0805	0300	93	19.0	44,030	2.2	
211	0810	0410	43	21.0	43,891	1.9	.8
214	0805	0540	93	17.0	44,815	2.4	
215	0807	0640	23	16.5	46,095	3.0	
217	0754	2000	290	17.0	44,000	2.0	
218	1212	0900	230	18.0	43,801	3.0	.4
219	1557	0930	150	17.5	45,660	3.1	1.0
222	0845	0010	230	19.0	43,801	4.0	
223	0746	0100	93	19.0	43,801	2.4	
224	0750	0200	230	18.5	44,000	2.9	
225	0750	0310	150	19.0	44,201	2.8	

STATION 4 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0825	2020	91	17.5	41,700	6.4	2.0
175	0920	2215	230	20.5	36,450	5.9	4.1
176	0900	2315	230	17.5	40,240	5.4	4.4
177	0917	2346	1,500	18.5	37,760	3.6	2.0
180	0828	0230	230	18.5	39,437	4.0	1.4
181	0817	0320	2,300	22.0	35,720	5.4	
182	0818	0445	24,000	19.0	37,923	5.1	2.5
183	0844	0510	7,500	19.0	39,570	7.2	
184	0839	0550	46,000	19.5	37,100	7.3	4.3
187	0905	0800	2	21.0	42,826	8.7	4.0
188	0808	2050	91	20.5	41,320	9.1	
189	0806	2130	2,300	20.0	40,290	7.2	
190	0812	2120	430	20.5	40,744	7.7	5.2
191	0814	2330	430	21.5	40,902	9.2	
194	1150	0120	930	24.0	36,894	8.4	
195	1146	0120	11,000	22.0	36,343	7.2	
197	1147	0400		20.0	32,542	2.8	2.4
198	0813	0520	46,000	20.0	36,040	3.0	
198	0813	0520	24,000	20.0		3.0	
201	0813	2000	4,300	22.0	38,611	7.4	
202	0803	2030	93	22.0	38,765	6.5	
203	0822	2140	4,600	23.5	33,902	8.1	
204	0809	2240	1,100	24.0	36,720	6.9	
205	0811		460	24.5	29,755	6.5	
206	0821	2330	4,600	22.5	31,286	6.4	
209	0926	0220	46,000	24.0	32,433	8.4	
210	0816	0300	4,600	23.0	35,772	10.0	
211	0821	0410	2,400	24.0	34,400	9.3	6.0
214	0816	0540	930	19.0	37,090	5.7	
215	0816	0640	3,900	19.0	40,166	5.2	
217	0804	2000	30	18.5	41,191	6.5	
218	1221	0900	24,000	20.0	39,591	4.9	2.5
219	1548	0930	46,000	21.0	40,333	4.2	2.8
222	0853	0010	4,300	20.0	41,191	4.1	
223	0755	0100	2,300	20.0	41,905	2.8	
224	0758	0200	15,000	20.0	41,545	3.1	
225	0800	0310	9,300	21.0	41,191	4.1	

STATION 4 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0828	2020	30	16.5	43,700	5.7	.5
175	0920	2215	23	17.5	43,380	5.9	.5
176	0900	2315	43	16.5	42,920	5.8	1.1
177	0917	2346	15	16.5	44,320	5.5	.6
180	0828	0230	14	16.5	44,840	4.6	.2
181	0817	0320	750	20.5	37,200	4.6	
182	0818	0445	930	16.0	44,671	4.8	.4
183	0844	0510	4,600	17.0	44,450	3.4	.6
184	0832	0550	230	17.0	44,421	4.5	.8
187	0905	0800	43	19.0	45,023	3.3	5.3
188	0808	2050	23	18.5	43,940	3.5	
189	0806	2130	9	18.0	43,920	5.7	
190	0812	2120	23	19.0	44,820	4.2	.6
191	0814	2330	39	19.0	44,960	4.1	
194	1150	0120	23	21.0	44,273	4.1	
195	1146	0120	1,500	18.5	44,374	4.8	
197	1147	0400	2,400	18.0	44,030	4.8	.3
198	0813	0520	2,400	18.0	44,633	3.5	
201	0813	2000	93	20.5	34,750	4.0	
201	0813	2000	43	20.5		4.0	
202	0803	2030	230	20.0	42,863	3.8	
203	0822	2140	93	21.0	42,490	4.3	
204	0809	2240	43	21.0	35,382	4.4	
205	0811		93	20.7	43,053	4.3	
206	0821	2330	460	19.0		4.2	
206	0821	2330	93	19.0	42,770	4.2	
209	0926	0220	210	19.0	44,030	3.5	
210	0816	0300	93	19.0	44,230	2.7	
211	0821	0410	230	19.5	46,130	2.3	.5
215	0816	0640	36	16.0	45,130	4.0	
217	0804	2000	30	17.0	45,660	2.7	
218	1221	0900	73	19.0	44,000	3.1	.5
219	1548	0930	9	18.5	44,201	3.5	.4
222	0853	0010	230	19.0	45,023	3.7	
223	0755	0100	430	18.5	44,000	3.8	
224	0758	0200	150	17.5	43,801	2.8	
225	0800	0310	73	18.5	44,040	3.5	

STATION 5 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIME OF TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0836	2020	4	17.5	42,300	7.4	2.1
175	0933	2203	210	19.0	40,230	9.6	5.1
176	0914	2253	93	17.0	42,000	8.7	3.6
177	0930	2344	43	17.5	41,850	7.5	3.2
180	0840	0225	93	18.5	42,600	5.1	1.0
181	0829	0316	150	22.0	40,200	7.0	
182	0829	0408	93	19.5	37,645	7.6	4.3
183	0857	0457	2,400	19.0	40,880	8.3	4.4
184	0843	0545	930	19.5	38,222	9.3	4.4
187	0915	0757	23	21.0	42,931	8.4	2.9
188	0819	2013	39	20.4	42,590	9.1	
189	0818	2053	430	20.0	42,241	9.1	
190	0823	2135	230	20.5	42,500	8.9	3.0
191	0828	2220	430	21.0	43,100	8.5	
194	1131	0053	23	23.0	40,753	10.1	
195	1133	0155	240	21.5	38,956	11.8	
197	1136	0400	2,400	19.5	42,304	4.4	1.0
198	0825	0456		20.0	40,542	4.2	
198	0825	0456	11,000	20.0		4.2	
201	0825	0736	11,000	23.0	36,171	6.5	
201	0825	0736	930	23.0		6.5	
202	0814	2000	75	22.5	39,234	8.3	
203	0831	2047	460	23.5	38,160	8.5	
204	0820	2135	460	23.5	36,720	8.6	
205	0822	2224	460	23.8	37,713	7.7	
206	0835	2310	2,400	23.0	33,552	8.4	
209	0939	0144	930	24.0	36,580	10.9	
210	0827	0240	460	24.0	37,570	9.6	
211	0835	0335	43	24.0	38,230	8.4	3.7
214	0826	0604	460	18.5	37,520	4.6	
215	0827	0648	1,100	19.0	40,333	4.5	
217	0815	0812	93	18.0	42,090	7.1	
218	1231	0854	2,400	20.0	42,271	4.7	1.9
219	1538	0938	430	20.5	42,090	8.3	3.2
222	0905	2336	150	19.0	42,460	5.7	
223	0805	0034	39	19.0	42,271	4.9	
224	0808	0137	43	20.0	42,460	5.2	
225	0810	0242	230	20.5	43,604	7.0	

STATION 6 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0841	2020	43	17.0	42,000	7.2	2.0
175	0939	2203	230	19.5	40,510	7.5	2.9
176	0919	2253	93	17.5	41,910	8.6	4.6
177	0936	2344	93	17.5	41,140	6.9	3.7
180	0845	0225	230	18.5	40,580	5.4	1.6
181	0835	0316	150	22.5	37,340	5.8	
182	0835	0408	2,400	19.0	44,813	7.5	2.3
183	0902	0457	750	19.5	39,000	10.4	6.3
184	0850	0545	4,600	19.5	38,200	9.0	4.8
187	0920	0757	43	21.5	42,931	9.1	4.3
188	0824	2013	43	20.0	41,320	8.3	
189	0823	2053	930	20.0	41,915	8.7	
190	0827	2135	21	20.0	42,641	8.9	4.0
191	0832	2220	39	21.5	43,100	8.5	
194	1123	0053	75	23.0	40,415	10.2	
195	1128	0155	3,000	22.0	37,390	10.0	
197	1131	0400		19.5	37,140	3.0	1.8
198	0833	0456		20.0	34,630	3.4	
198	0833	0456		20.0		3.4	
201	0831	0736	121	23.0	34,750	8.1	
202	0819	2000	150	22.5	39,080	8.1	
203	0835	2047	43	22.5	38,920	6.8	
204	0824	2135	240	23.5	42,863	8.3	
205	0827	2224	430	23.7	35,904	7.4	
206	0841	2310	24,000	23.0	27,880	8.1	
209	0943	0144	2,400	23.5	35,904	11.3	
210	0834	0240	1,500	23.5	35,904	9.7	
211	0839	0335	2,400	23.5	35,054	8.7	6.0
214	0831	0604	230	20.0	35,460	5.7	
215	0832	0648	2,300	19.0	38,800	5.0	
217	0820	0812	30	19.5	40,502	8.2	
218	1235	0854	2,400	20.0	40,166	6.4	3.1
219	1533	0938	4,300	20.0	41,905	4.8	1.9
222	0910	2336	91	20.0	42,090	5.4	
223	0815	0034	230	19.0	42,271	4.5	
224	0813	0137	4,300	21.0	41,724	5.9	
225	0815	0242	1,500	21.0	41,191	4.5	

STATION 6 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0841	2020	93	15.5	44,700	5.9	.4
175	0939	2203	9	17.5	43,990	6.1	.4
176	0919	2253	43	15.5	44,270	5.7	1.5
177	0936	2344	23	16.0	44,200	5.7	.6
180	0845	0225	23	16.5	46,350	4.9	.2
181	0835	0316	4	18.5	44,773	5.4	
182	0835	0408	150	16.0	39,280	5.3	.3
183	0902	0457	390	17.0	43,900	4.2	.7
184	0850	0545	430	16.5	44,400	4.9	.4
187	0920	0757	23	19.0	45,136	2.9	.5
188	0824	2013	23	18.0	44,337	3.0	
189	0823	2053	23	18.0	45,910	5.5	
190	0827	2135	23	18.0	45,140	4.9	.5
191	0832	2220	43	18.5	44,383	3.8	
194	1123	0053	23	20.0	44,475	20.0	
195	1128	0155	9	19.0	44,273	4.4	
197	1131	0400	460	18.0	44,330	4.7	.2
198	0833	0456	1,100	19.0	44,030	3.8	
201	0831	0736	11,000	20.5	42,304	3.8	
201	0831	0736	93	20.5		3.8	
202	0819	2000	43	20.0	37,423	4.6	
203	0835	2047	43	20.0	44,230	4.8	
204	0824	2135	75	26.9	38,310	4.9	
205	0827	2224	43	20.2	43,830	4.6	
206	0841	2310	240	19.0	42,304	4.2	
206	0841	2310	240	19.0		4.2	
209	0943	0144	240	19.0	44,230	4.2	
210	0834	0240	95	19.5	45,900	3.3	
211	0839	0335	390	21.0	35,963	5.6	2.2
214	0831	0604	75	18.0	44,201	3.5	
215	0832	0648	93	17.0	45,880	1.5	
217	0820	0812	23	17.0	44,610	3.1	
218	1235	0854	43	18.0	44,000	2.9	.4
219	1533	0938	93	17.5	46,095	4.6	.4
222	0910	2336	4	18.0	45,023	3.9	
223	0815	0034	230	18.0	44,000	4.1	
224	0813	0137	43	18.5	44,201	4.2	
225	0815	0242	91	18.5	44,201	3.7	

STATION 7 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0847	2020	43	17.5	42,500	8.4	3.6
175	0945	2203	39	19.5	42,710	9.0	3.7
176	0925	2253	150	17.5	41,670	9.8	4.7
177	0942	2344	93	18.0	41,500	7.1	4.8
180	0850	0225	23	18.5	40,580	5.7	1.4
181	0840	0316	43	21.0	39,720	7.0	
182	0840	0408	930	18.0	42,140	6.1	1.8
183	0909	0457	430	19.5	40,485	10.0	4.4
184	0858	0545	2,100	19.0	41,640	7.4	2.8
187	0923	0757	23	21.5	42,094	9.1	5.0
188	0828	2013	43	19.3	42,460	8.2	
189	0828	2053	930	19.5	42,241	8.5	
190	0831	2135	93	21.0	42,000	9.0	3.9
191	0838	2220	150	21.5	42,746	8.9	
194	1120	0053	460	24.0	40,250	10.7	
195	1122	0155	4,600	22.0	36,141	10.7	
197	1127	0400		20.0	36,306	2.9	1.9
198	0837	0456	4,600	19.5	41,404	3.7	
198	0837	0456	1,100	19.5		3.7	
201	0836	0736	930	22.5	38,611	8.1	
201	0836	0736	93	22.5		8.1	
202	0823	2000	23	23.5	36,720	9.5	
203	0840	2047	460	23.5	38,765	8.4	
204	0829	2135	750	26.9	36,306	6.8	
205	0831	2224	43	23.7	36,860	7.2	
206	0844	2310	240	22.5	34,775	7.3	
209	0948	0144	930	22.5	38,765	9.0	
210	0838	0240	2,400	23.0	36,442	10.0	
211	0843	0335	240	23.5	37,350	7.6	3.4
214	0835	0604	23	20.0	38,566	5.3	
217	0823	0812	9	18.0	41,191	7.5	
218	1239	0854	43	20.0	41,905	5.4	1.3
219	1529	0938	2,400	22.0	40,672	5.3	3.7
222	0914	2336	93	19.0	42,363	5.6	
223	0817	0034	430	20.0	42,271	5.5	
224	0816	0137	430	20.0	42,090	5.1	
225	0817	0242	4,600	21.0	41,191	7.7	

STATION 8 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0858	0850	23	16.5	42,800	7.7	2.0
175	0959	2203	93	20.0	42,180	10.1	4.7
176	0934	2253	43	17.5	41,630	8.4	4.9
177	1003	2344	43	19.0	40,670	8.4	
180	0900	0225	23	18.5	40,920	5.8	1.7
181	0849	0316	230	21.5	37,740	6.6	
182	0848	0408	1,500	19.0	40,081	8.0	4.4
183	0920	0457	430	19.5	40,530	9.4	4.6
184	0905	0545	930	20.0	39,810	9.6	5.0
187	0932	0757	75	21.5	42,987	10.2	5.4
188	0838	2013	23	21.0	40,670	8.8	
189	0838	2053	230	19.5	42,710	7.2	
190	0840	2135	23	20.5	42,543	8.4	4.4
191	0847	2220	23	22.0	42,571	9.1	
194	1110	0053	43	22.5	41,450	8.6	
195	1114	0155	1,100	21.5	40,500		
197	1117	0400		19.5	40,542	4.0	1.6
198	0845	0456		20.0	37,280	4.2	
198	0845	0456		20.0		4.2	
201	0845	0736	430	22.5	38,920	9.7	
202	0831	0826	210	22.5	34,750	7.8	
203	0847	2047	93	23.5	37,423	8.8	
204	0837	2135	3,900	23.0	44,230	7.9	
205	0840	2224	23	23.7	35,000	8.0	
206	0853	2310	150	22.5	35,382	7.2	
209	0958	0144	930	23.0	37,000	9.4	
210	0847	0240	390	23.0	37,280	9.4	
211	0852	0335	460	23.0	34,930	8.5	4.9
214	0844	0604	150	19.0	38,875	5.7	
215	0843	0648	930	19.0	40,333	5.8	
217	0832	0812	43	19.0	42,090	6.4	
218	1247	0854	240	20.0	41,191	6.2	2.1
219	1519	0938	4,600	20.0	40,166	5.7	3.0
222	0923	2336	15	19.0	42,341	5.4	
223	0824	0034	430	20.0	42,090	4.4	
224	0824	0137	430	20.0	41,545	4.7	
225	0825	0242	750	21.0	41,724	6.6	

STATION 8 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0858	0850	43	15.0	44,700	6.3	.2
175	0959	2203	9	17.0	44,500	6.9	.3
176	0934	2253	23	15.0	44,440	6.3	1.0
177	1003	2344	43	16.5	44,950	6.1	.8
180	0900	0225	3	16.5	46,460	5.7	.2
181	0849	0316	9	17.0	45,455	5.8	
182	0848	0408	39	16.0	44,725	5.5	.3
183	0920	0457	430	16.5	45,030	5.0	.5
184	0905	0545	43	16.5	45,746	5.6	
187	0932	0757	23	18.5	45,770	3.3	.3
188	0838	2013	3	17.5	46,020	3.4	
189	0838	2053	4	18.0	46,321	5.7	
190	0840	2135	15	18.0	45,183	5.1	.4
191	0847	2220	4	19.5	44,383	3.8	
194	1110	0053	9	19.0	44,680	4.8	
195	1114	0155	21	18.0	44,475	4.3	
197	1117	0400	1,100	17.0	45,256	5.3	
198	0845	0456	1,100	18.0	44,633	5.2	
201	0845	0736	43	19.5	38,160	3.8	
201	0845	0736	23	19.5		3.8	
202	0831	0826	43	20.0	42,490	4.9	
203	0847	2047	23	20.0	44,330	5.4	
204	0837	2135	23	20.5	42,360	5.4	
205	0840	2224	43	19.8	44,030	5.0	
206	0853	2310	39	18.0	44,230	5.0	
206	0853	2310	23	18.0		5.0	
209	0958	0144	240	19.0	44,230	4.1	
210	0847	0240	39	19.0	45,900	3.6	
211	0852	0335	23	18.5	45,802	3.7	.5
214	0844	0604	9	16.0	46,095	4.3	
215	0843	0648	43	16.5	46,095	5.0	
217	0832	0812	9	15.5	45,130	3.9	
218	1247	0854	23	17.0	44,302	4.4	.2
219	1519	0938	43	17.0	46,095	5.0	.2
222	0923	2336	7	17.5	44,201	4.5	
223	0824	0034	43	18.5	44,201	4.1	
224	0824	0137	23	17.5	45,450	4.6	
225	0825	0242	43	18.5	45,023	3.8	

STATION 9 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0908	0850	23	17.0	44,500	7.3	1.9
175	1010	2203	23	19.5	10,030	10.8	6.7
176	0944	2253	23	16.6	43,050	9.0	3.8
177	1014	2344	23	18.5	41,670	8.5	5.6
180	0909	0225	15	18.5	42,880	6.9	3.1
181	0856	0316	93	22.5	39,453	8.2	
182	0857	0408	460	17.0	43,822	5.6	1.4
184	0915	0545	430	19.5	41,720	10.0	5.4
187	0939	0757	43	21.0	43,304	9.4	2.7
188	0846	0839	43	20.5	42,400	9.1	
189	0846	2053	240	20.0	42,150	7.7	
190	0850	2135	23	21.0	43,103	9.7	3.6
190	0850	2135	2	21.0			
191	0856	2220	15	21.5	42,922	9.6	
194	1103	0053	110	22.0	42,350	8.5	
195	1108	0155		22.0	40,670	8.3	
197	1111	0400		20.0	40,711	5.0	2.0
198	0854	0456		20.0	37,570	6.2	
198	0854	0456		20.0		6.2	
201	0854	0736	93	22.0	44,330	7.7	
202	0840	0826	93	22.5	40,541	7.5	
203	0855	2047	150	23.5	38,920	9.3	
204	0845	2135	460	23.5	37,570	7.8	
205	0847	2224	460	24.0	37,713	7.4	
206	0902	2310	110	22.5	37,423	7.1	
209	1009	0144	930	23.5	37,423	9.8	
210	0856	0240	15	23.0	38,920	9.4	
211	0900	0335	91	24.0	38,605	8.3	4.9
214	0852	0604	390	19.0	41,191	5.5	
215	0835	0648	430	18.0	40,000	5.2	
215	0850	0648	930	19.0	40,844	6.2	
217	0840	0812	2	19.0	42,090	7.5	
218	1255	0854	2	19.5	42,090	7.6	2.6
219	1511	0938	930	20.5	42,271	6.9	2.9
222	0930	2336		19.0	43,214	5.7	
223	0835	0034	750	20.0	42,090	4.8	
224	0833	0137	2,300	20.0	41,545	5.4	
225	0830	0242	150	21.5	42,090	8.2	

STATION 9 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0908	0850	23	16.0	44,400	5.8	
175	1010	2203	43	17.0	43,430	6.7	.5
176	0944	2253	43	16.5	43,500	5.9	.8
177	1014	2344	23	17.5	43,160	5.7	.9
180	0909	0225	9	17.5	43,840	6.2	1.0
181	0856	0316	7	20.0	43,103	5.7	
182	0857	0408	43	16.0	44,130	4.0	.4
184	0915	0545	91	18.5	42,934	6.9	3.3
187	0939	0757	23	19.5	44,356	6.7	1.7
188	0846	0839	2	19.0	44,140	4.9	
189	0846	2053	4	19.0	44,324	5.7	
190	0850	2135	7	19.5	43,950	5.2	1.0
191	0856	2220	2	20.5	43,460	5.6	
194	1103	0053	8	21.0	42,720	3.7	
195	1108	0155	120	20.5	43,100	4.9	
197	1111	0400		19.0	44,230	4.3	.7
198	0854	0456		19.5	42,490	5.6	
201	0854	0736	23	20.5	43,440	4.6	
201	0854	0736	75	20.5		4.6	
202	0840	0826	93	21.0	43,830	4.4	
203	0855	2047	43	21.0	43,830	4.0	
204	0845	2135	43	21.5	41,760	4.5	
205	0847	2224	23	21.8	42,675	4.5	
206	0902	2310	23	21.0		4.8	
206	0902	2310	9	21.0	41,581	4.8	
209	1009	0144	240	21.0	43,244	2.9	
210	0856	0240	93	20.0	43,632	2.8	
211	0900	0335	93	21.0	42,220	2.7	1.6
214	0852	0604	93	18.0	44,000	4.0	
215	0850	0648	93	17.0	44,000	3.2	
217	0840	0812	4	18.0	43,702	5.4	
218	1255	0854	23	19.0	43,604	4.8	.6
219	1511	0938	240	19.0	44,000	6.1	1.6
222	0930	2336		18.5	42,643	5.5	
223	0835	0034	240	18.5	43,604	4.4	
224	0833	0137	460	19.0	43,801	4.3	
225	0830	0242	93	20.0	44,000	4.3	

STATION 10 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
175	1023	2212	93	19.5	43,160	9.5	2.9
176	0957	2300	43	17.5	42,580	9.4	6.0
177	1028	2353	23	19.0	41,670	8.4	5.9
173	0923	0900	15	17.5	43,000	10.6	8.0
180	0921	0235	43	19.0	41,670	4.8	1.0
181	0910	0326	23	22.0	40,481	4.9	
182	0910	0418	430	18.5	41,905	4.9	.8
183	0937	0507	390	19.5	42,680	7.1	1.5
184	0933	0555	230	20.5	42,060	7.2	1.9
187	0952	0757	93	22.0	42,620	9.0	4.0
188	0900	0839	460	21.0	43,160	8.8	
189	0857	2103	460	21.0	42,094	8.2	
190	0900	2145	150	21.5	41,960	9.7	
191	0907	2230	9	23.0	41,720	7.8	
194	1049	0100	110	22.0	40,924	9.6	
195	1054	0205		21.5	40,753		
197	1057	0410	93	19.0	41,493	4.0	.6
198	0910	0506		20.5		3.9	
198	0910	0506		20.5	38,920	3.9	
201	0908	0746	230	23.5	39,000	9.0	
202	0853	0836	430	23.0	36,720	8.9	
203	0907	0900	240	23.5	38,920	7.5	
204	0856	2145	1,100	24.0	35,641	9.3	
205	0900	2233	460	24.5	34,503	7.6	
206	0915	2319	230	22.5	36,580	6.2	
209	1022	0153	430	24.0	36,442	10.4	
210	0911	0249		24.5	37,423	5.1	
211	0915	0334	2	24.0	37,656	4.1	.9
214	0905	0613	73	18.0	41,905	4.3	
215	0903	0657	230	19.0	42,832	5.7	
217	0852	0821	36	19.0	42,090	7.7	
218	1307	0901	230	20.0	42,271	4.4	.7
219	1452	0947	2	20.0	43,801	4.6	.7
222	0940	2345	4	18.5	42,643	5.5	
223	0843	0043	91	19.0	43,022	3.9	
224	0943	0146	91	21.0	42,090	5.0	
225	0845	0251	91	23.0	42,090	5.5	

STATION 10 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	0924	0900	15	16.0	44,200	6.3	1.0
175	1023	2212	2	17.0	44,410	7.0	.8
176	0957	2300	43	17.0	43,160	9.0	1.6
177	1028	2353	9	17.5	43,160	6.7	.8
180	0921	0235	9	18.5	42,900	5.2	.8
181	0910	0326	7	20.5	42,735	5.2	
182	0910	0418	23	16.5	45,350	4.7	.1
183	0937	0507	230	19.0	42,720	7.2	1.2
184	0933	0555	210	18.0	44,490	4.3	1.2
187	0952	0757	23	21.0	43,480	7.4	2.0
188	0900	0839	4	19.5	43,660	5.8	
189	0857	2103	4	19.0	45,480	5.0	
190	0900	2145	4	19.5	43,670	5.1	2.0
191	0907	2230	2	21.0	43,460	6.2	
194	1049	0100	14	21.0	42,350	6.2	
195	1054	0205	120	21.0	42,533	5.8	
197	1057	0410		19.0	42,490	3.8	.3
198	0910	0506		20.5	38,920	3.8	
201	0908	0746	21	22.0	42,304	5.4	
201	0908	0736	9	22.0		5.4	
202	0853	0836	29	21.5	42,304	4.4	
203	0907	0900	93	21.0	42,675	4.6	
204	0856	2145	43	21.0	43,632	5.3	
205	0900	2233	43	21.2	43,053	3.0	
206	0915	2319	23	20.0		3.2	
206	0915	2319	23	20.0	42,770	3.1	
209	1022	0153	43	21.5	42,490	2.3	
210	0911	0249	93	23.0	39,880	5.1	
211	0915	0334	23	22.5	40,800	4.7	1.5
214	0905	0613	43	18.0	42,643	3.8	
215	0903	0657	23	19.0	43,604	5.0	
217	0852	0821	23	18.5	41,905	6.4	
218	1307	0901	43	19.5	42,090	4.0	.7
219	1452	0947	64	20.0	43,022	4.4	.3
222	0940	2345	7	17.5	44,000	3.5	
223	0843	0043	23	19.0	43,801	3.6	
224	0943	0146	43	19.5	43,604	3.7	
225	0845	0251	23	21.5	41,905	5.0	

STATION 11 TOP

	TIME OF						
YEAR (DAYS) (1)	DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1014	0850	15	17.2	43,800	8.1	2.0
175	1117	1030	2	19.5	42,970	7.6	1.5
176	1100	2253	43	17.0	43,000	9.6	3.7
177	1148	2344	9	20.5	43,320	8.9	6.4
180	1034	0225	2	21.0	42,682	7.1	
182	1005	0408	23	18.0	43,246	6.5	3.0
183	1033	0459	93	19.5	42,710	8.0	4.1
184	1032	0545	430	21.5	44,000	9.3	5.1
187	1115	0757	2	20.0	43,125	7.8	3.2
188	1000	0837	460	20.0	43,000	6.7	
189	0958	0920	240	21.5	41,610	8.5	
190	0958	2135	43	21.0	43,632	6.8	1.6
191	1002	2220	7	21.0	43,783	6.6	
194	0953	0053	19	21.5	40,753	8.8	
195	0958	0155	900	22.0	40,924	15.2	
197	0958	0400		19.5	38,160	5.1	2.7
198	1003	0456		22.0	39,000	6.8	
201	0958	0736	43	22.5	42,304	6.4	
202	0947	0826	40	21.5	42,304	5.8	
203	0958	0914	43	23.0	40,374	8.3	
203	0958	9999	93	23.0		8.3	
204	0957	2135	460	25.0	37,713	9.2	4.6
205	0959	2224	23	24.0	40,210	8.0	
206	1013	2310	240	23.0	32,871	8.7	
209	1117	0144	7	25.0	36,856	11.1	
210	1008	0240	23	24.5	38,611	9.0	
211	1018	0335	43	25.0	37,154	9.0	3.6
214	0958	0604		20.0	37,961	5.7	
215	0953	0648	1,100	20.0	37,665	6.6	
217	0955	0812	23	18.0	44,000	5.9	
218	1358	0854	9	20.0	41,905	7.8	3.3
219	1342	0938		20.0		7.4	2.7
222	1025	2336	23	19.0	44,000	5.1	
223	1030	0034	64	20.0	41,905	5.7	
224	0940	0137	240	21.0	41,620	7.2	
225	0925	0242	9	21.0	40,500	5.5	

STATION 11 BOTTOM

	TIME OF						
YEAR (DAYS) (1)	DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1014	0850	39	16.5	44,500	6.6	.3
175	1117	1030	4	18.5	44,650	7.3	.6
176	1100	2253	4	17.0	43,730	7.7	1.3
177	1148	2344	4	18.5	43,780	6.5	
180	1034	0225	2	19.5	42,880	6.0	
182	1005	0408	430	17.0	43,644	5.8	.6
183	1033	0459	23	18.5	43,822	6.6	1.2
184	1032	0545	230	20.5	42,200	8.9	3.8
187	1115	0757	23	19.0	44,483	6.0	2.0
188	1000	0837	2	19.0	44,620	6.8	
189	0958	0920	4	20.0	44,941	5.4	
190	0958	2135	9	20.0	44,174	5.5	.5
191	1002	2220	2	20.5	44,170	5.4	
194	0953	0053	7	21.0	44,072	5.4	
195	0958	0155	9	20.5	42,910	5.8	
197	0958	0400		18.0	43,830	5.4	.9
198	1003	0456	430	19.5	43,632	4.6	
201	0958	0736	230	20.5	44,030	5.8	
202	0947	0826	43	20.5	44,230	5.2	
203	0958	0914	23	21.0	44,030	4.6	
204	0957	2135	23	22.0		4.3	.3
205	0959	2224	23	22.9	42,304	4.8	
205	0959	2224	23	22.9		4.8	
206	1013	2310	93	21.5	46,542	4.9	
209	1117	0144	23	20.5	44,430	2.5	
210	1008	0240	15	21.0	42,490	2.8	
211	1018	0335	43	22.0	42,743	2.4	.8
214	0958	0604	23	19.0	42,090	5.4	
215	0953	0648	1	18.0	43,801	3.6	
217	0955	0812	9	17.5	43,604	4.3	
218	1358	0854	7	19.5	42,090	7.0	1.8
219	1342	0938	23	18.0	44,000	5.4	.8
222	1025	2336	4	19.0	43,801	4.5	
223	1030	0034	23	19.5	43,801	4.1	
224	0940	0137	23	20.0	42,363	5.7	
225	0925	0242	4	20.0	43,600	5.0	

STATION 12 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1025	0850	93	17.0	42,950	7.5	1.6
175	1123	1030	75	19.5	41,990	8.9	3.3
176	1105	2253	9	17.0	43,910	10.6	4.2
177	1156	2344	43	19.0	43,390	10.4	7.9
182	1012	0408	93	17.5	43,202	6.6	2.6
183	1045	0459	430	20.0	42,420	8.4	2.9
184	1048	0545	1,200	21.5	42,550	11.2	4.7
187	1122	0757	23	20.0	42,770	9.2	2.9
188	1007	0837	43	21.0	43,580	8.4	
189	1013	0920	240	22.0	42,723	8.8	
190	1003	1000	7	20.5	43,783	7.9	2.2
191	1008	2220	7	21.0	43,973		
194	0948	0053	49	21.5	43,680	8.8	
195	0951	0155		21.0	41,802	9.3	
197	0951	0400		19.0	42,121	5.5	2.2
198	1014	0456	4,600	21.5	41,404	6.4	
201	1004	0736	23	22.0	42,341	7.1	
202	0952	0826	9	22.0	42,304	6.7	
203	1005	0914	43	23.0	40,711	8.4	
203	1005	9999	240	23.0		8.4	
204	1002	1000	1,160	24.0	37,423	9.4	6.1
205	1008	2224	43	23.2	41,760	7.7	
206	1019	2310	240	24.0	38,920	7.8	
209	1124	0144	430	25.0	36,306	11.4	
210	1017	0240	39	23.5	40,375	8.7	
211	1025	0335	23	24.0	38,720	8.8	4.6
214	1006	0604	43	19.5	40,672	6.5	
215	0958	0648	430	20.0	41,634	6.9	
217	1001	0812	240	18.5	42,460	7.1	
218	1404	0854	9	19.0	43,022	6.9	2.0
219	1347	0938	93	19.5	42,271	7.1	3.3
222	1032	2336	9	18.5	43,801	5.9	
223	1040	0034	240	19.5	42,643	6.1	
224	0945	0137		20.5	41,724	6.8	
225	0930	0242	43	21.5	43,000	9.6	

STATION 12 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1025	0850	4	16.0	44,300	7.9	.6
175	1123	1030	23	17.5	44,560	7.8	1.2
176	1105	2253	9	17.0	43,630	6.9	1.3
177	1156	2344	4	17.5	45,480	6.1	1.2
180	1040	0225	4	19.0	42,682	6.3	
182	1012	0408	23	17.0	44,434	4.7	.7
183	1045	0459	95	18.0	44,553	4.7	.5
184	1048	0545	93	19.0	45,250	5.0	1.2
187	1122	0757	4	19.0	43,490	6.0	1.0
188	1007	0837	2	19.5	44,620	5.3	
189	1013	0920	9	19.5	42,591	5.8	
190	1003	1000	3	19.5	44,300	6.0	.9
191	1008	2220	4	20.0	43,850	6.4	
194	0948	0053	110	21.0	44,273	5.8	
195	0951	0155	15	20.0	44,072	5.3	
197	0951	0400		18.0	44,230	5.5	.5
198	1014	0456	230	19.5	44,230	4.0	
201	1004	0736	9	20.5	44,030	6.2	
202	0952	0826	23	20.5	44,230	5.6	
203	1005	0914	15	20.5	43,830	5.4	
204	1002	1000	75	21.0		5.4	.5
205	1008	2224	39	22.7	42,304	6.8	
205	1008	2224	9	22.7		6.8	
206	1019	2310	43	20.5	42,304	5.3	
209	1124	0144	9	21.5	43,830	5.0	
210	1017	0240	93	21.0	42,304	3.6	
211	1025	0335	23	21.5	42,000	2.5	1.3
214	1006	0604	150	19.0	41,540	5.8	
215	0958	0648	23	17.0	45,023	5.2	
217	1001	0812	20	17.5	45,023	4.1	
217	1001	0812	39	17.5			
218	1404	0854	43	18.5	43,022	6.1	1.3
219	1347	0938	240	18.0	43,022	5.9	.7
222	1032	2336	4	18.5	44,000	5.3	
223	1040	0034	4	18.5	44,200	4.6	
224	0945	0137	43	18.5	44,000	4.0	
225	0930	0242	29	20.0	44,400	4.7	

STATION 13 TOP

	TIME OF						
YEAR (DAYS) (1)	DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1034	0850	2	17.2	43,300	10.6	3.7
175	1134	1030	2	19.0	43,400	12.9	
176	1116	2253	9	17.0	43,800	11.5	
177	1205	2344	23	18.5	44,000	3.5	2.8
180	1050	0225	4	20.0	42,880	8.5	3.9
182	1022	0408	20	18.5	43,950	7.8	3.3
183	1053	0459	230	20.5	42,931	9.6	3.9
184	1059	0545	430	21.0	42,740	9.5	
187	1128	0757	240	20.0	43,640	8.5	2.8
188	1016	0837	93	21.0	42,680	10.0	
189	1023	0920	43	23.0	43,243	8.0	
190	1011	1000	23	21.0	43,420	8.8	3.4
191	1016	2220	93	21.0	43,913	8.7	
194	0939	0053	21	22.0	43,680	9.0	
195	0940	0155		21.5	41,983	10.4	
196	1024	0257	8	20.0	43,100	6.5	
197	0944	0400	110	19.0	43,244	6.2	1.4
198	1020	0456	4,600	21.0	39,880	6.6	
201	1012	0736	9	22.5	42,121	7.5	
202	1000	0826	43	23.0	41,940	9.2	
203	1013	0914	43	22.0	42,304	6.9	
203	1013	9999	23	22.0		6.9	
204	1010	1000	43	23.5	40,373	7.4	2.0
205	1018	2224	23	23.8	40,800	8.9	
206	1027	2310	240	23.0	35,904	9.0	
209	1132	0144	93	24.0	36,171	11.9	
210	1025	0240	39	23.0	40,373	9.5	
211	1031	0335	23	24.5	40,250	8.7	5.6
214	1015	0604	43	18.5	42,643	6.0	
215	1006	0648	1,100	20.0	42,050	7.1	
217	1010	0812	23	18.5	43,022	7.7	
218	1412	0854	9	19.0	43,801	5.8	1.1
219	1339	0938	43	19.0	42,643	6.4	1.2
222	1040	2336	4	19.0	43,801	5.3	
223	1043	0034	1,100	19.5	43,604	5.7	
224	0951	0137	240	20.5	43,410	6.4	
225	0935	0242	240	22.0	42,100	9.9	

STATION 13 BOTTOM

	TIME OF						
YEAR (DAYS) (1)	DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1034	0850	4	16.0	44,600	7.4	.4
175	1134	1030	2	17.0	45,290	7.3	.3
176	1116	2253	2	15.5	44,760	6.7	.6
177	1205	2344	9	17.0	44,410	6.7	
180	1050	0225	4	17.5	44,905	5.8	
182	1022	0408	230	16.0	45,590	6.0	.6
184	1059	0545	43	19.0	46,740	5.6	.2
185	1053	0459	23	17.5	45,695	5.3	.3
187	1128	0757	2	18.5	44,261	5.9	.7
188	1016	0837	4	18.0	45,010	5.3	
189	1023	0920	4	19.0	45,905	6.0	
190	1011	1000	4	19.0		6.2	
190	1011	1000	9	19.0	42,851	6.2	.5
191	1016	2220	2	19.5	44,670	6.8	
194	0939	0053	12	20.0	45,730	6.2	
195	0940	0155	2	20.0	44,273	5.9	
196	1024	0257		19.5	44,072	5.7	
197	0944	0400	21	16.5	45,256	5.7	.4
198	1020	0456	43	19.0	44,230	5.6	
201	1012	0736	20	20.0	44,430	5.0	
202	1000	0826	15	20.5	44,430	6.0	
203	1013	0914	43	20.0	44,230	5.8	
204	1010	1000	4	21.0	44,633	5.8	.1
205	1018	2224	23	22.0	44,030	6.1	
205	1018	2224	23	22.0		6.1	
206	1027	2310	15	20.0	43,244	6.0	
209	1132	0144	21	19.0	45,256	4.1	
210	1025	0240	150	20.0	44,230	2.8	
211	1031	0335	23	20.0	44,520	3.2	.1
214	1015	0604	240	16.0	46,540	5.0	
215	1006	0648	3	17.0	45,450	5.3	
217	1010	0812	43	16.5	45,880	4.0	
218	1412	0854	9	17.0	46,095	4.8	.1
219	1339	0938	9	17.0	44,610	5.3	.2
222	1040	2336		17.0	44,201	5.0	
223	1043	0034	23	18.0	45,234	5.2	
224	0951	0137	7	19.0	44,404	4.7	
225	0935	0242	7	18.5	44,500	4.0	

STATION 14 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1100	0847	4	16.5	44,400	8.8	.6
175	1203	1030	2	18.0	44,780	9.3	2.0
176	1145	1123	2	11.0	44,500	8.6	3.1
177	1230	1217	9	16.5	45,900	9.0	3.1
180	1117	0223	2	19.0	43,660	7.5	1.7
182	1049	0408	93	20.0	42,035	8.6	3.1
183	1125	0457	430	19.0	43,304	7.7	2.9
184	1126	0545	230	22.0	43,020	8.9	2.4
187	1153	0757	43	19.0	44,195	6.8	1.0
188	1040	0837	16	19.0	45,260	7.6	
189	1047	0920	240	22.0	44,742	8.6	
189	1047	0920	240	22.0	44,742	8.6	
190	1040	1000	240	20.0	44,780	8.3	1.8
191	1043	1040	43	19.5	45,140	8.1	
194	0913	0053	15	20.0	43,680	8.1	
195	0916	0155	10	20.0	43,680	7.6	
196	0959	0257		20.0	43,100	7.2	
197	0918	0400		19.0	41,940	7.2	2.2
198	1047	0456	930	20.0	42,121	8.2	
201	1036	0736	4	21.0	44,230	6.3	
202	1025	0826	23	21.5	44,030	7.4	
203	1038	0914	23	20.5	44,230	7.7	
203	1038	9999	9	20.5		7.7	
204	1035	1000	43	22.0		8.4	2.7
205	1049	1049	4	22.1	44,430	8.1	
206	1052	2310	4	20.5	44,230	7.4	
209	1200	0144		23.0	41,055	9.0	
210	1052	0240	75	23.0	41,404	7.8	
211	1100	0335		23.5	41,820	8.5	3.2
214	1040	0604	43	21.0	40,844	7.1	
215	1031	0648	93	21.0	42,070	6.8	
217	1036	0812	240	17.5	44,000	6.2	
218	1437	0854	9	20.0	45,234	5.6	.8
219	1313	0938	43	19.0	44,000	5.4	.4
222	1100	2336	9	17.5	44,000	6.0	
223	1105	0034	43	19.0	44,000	6.2	
224	1013	0137	9	21.0	44,404	6.8	
225	0957	0242	4	21.0	44,200	7.2	

STATION 14 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1100	0847	2	15.5	45,400	8.0	.6
175	1203	1030	7	16.0	45,950	7.5	
176	1143	1123	7	14.5	46,410	7.6	.1
177	1230	1217	2	15.5	46,800	7.5	.1
180	1117	0223	4	17.0	45,555	6.8	.5
182	1049	0408	23	16.5	45,814	6.8	.3
183	1125	0457	15	17.0	46,300	6.4	.2
184	1126	0545	93	19.0	45,340	6.5	.3
187	1153	0757	23	17.0	45,350	5.5	.3
188	1040	0837	4	17.0	46,390	6.6	
189	1047	0920	9	19.0	46,930	6.7	
190	1040	1000	23	18.0	47,311	6.8	.1
191	1043	1040	4	17.0	46,840	6.8	
194	0913	0053	14	17.0	46,603	6.5	
195	0916	0155	10	17.0	46,603	6.1	
196	0959	0257	12	16.0	46,830	6.3	
197	0918	0400	110	17.0	45,681	6.1	.2
198	1047	0456	230	18.0	44,840	5.7	
201	1036	0736		19.0	45,681	6.6	
202	1025	0826	4	19.5	45,681	6.6	
203	1038	0914	4	18.5	41,940	6.7	
204	1035	1000	4	19.5		6.5	
205	1049	1049	43	19.0	44,230	6.7	
205	1049	1049	9	19.0		6.7	
206	1052	2310	15	18.0	46,333	6.6	
209	1200	0144	43	18.0	46,114	6.0	
210	1052	0240		17.5	46,380	6.1	
211	1100	0335	4	18.5	45,782	5.8	.3
214	1040	0604	4	16.0	46,540	9.4	
215	1031	0648	9	19.5	45,880	5.8	
217	1036	0812	4	16.0	45,660	5.6	
217	1036	0812	15	16.0			
218	1437	0854	9	17.0	47,220	5.8	.3
219	1313	0938	9	17.0	45,023	5.7	.2
222	1100	2336	9	17.0	46,316	6.2	
223	1105	0034	23	17.5	46,540	5.8	
224	1013	0137	43	18.5	45,880	5.6	
225	0957	0242	21	18.0		5.6	

STATION 15 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1105	0847	7	16.5	44,500	8.1	1.4
175	1210	1030	23	19.5	43,590	10.4	3.9
176	1152	1123	43	15.5	44,780	8.4	2.6
177	1239	1217	15	17.0	44,622	8.3	2.4
180	1123	0223	4	19.5	44,834	7.1	1.7
182	1056	0408	930	19.5	43,162		3.3
183	1129	0457	930	19.0	43,233	8.2	3.3
184	1130	0545	230	20.5	42,740	8.4	2.2
184	1211	0600		20.4	22,940	3.3	
187	1200	0757	7	19.0	44,181	6.2	.7
188	1046	0837	14	19.5	44,710	7.9	
189	1052	0920	39	20.5	43,640	8.2	
190	1046	1000	43	19.0	45,291	8.0	2.2
191	1047	1040	240	19.5	45,910	7.8	
194	0908	0053	14	20.0	44,273	7.6	
195	0912	0155	110	20.0	42,533	7.5	
196	0954	0257		20.0	41,802	7.0	
197	0914	0400	110	19.0	40,882	6.6	2.0
198	1052	0456	430	21.5	41,212	8.9	
201	1042	0736	9	20.5	44,030	6.5	
202	1031	0826	93	20.5	44,230	7.0	
203	1043	0914	14	20.5	45,681	7.6	
203	1043	9999	9	20.5		7.6	
204	1040	1000	75	22.0	44,030	7.2	1.0
205	1057	1049	23	21.8	42,212	7.4	
206	1059	2310	4	21.0	43,053	7.7	
209	1204	0144	9	23.5	40,626	9.2	
210	1057	0240	23	23.0	42,304	7.5	
211	1105	0335	23	23.0	41,820	8.1	3.2
214	1046	0604	240	19.0	41,545	7.0	
215	1036	0648	75	20.0	42,090	6.5	
217	1042	0812	150	16.5	44,000	5.5	
218	1442	0854	93	19.5	44,000	5.8	
219	1308	0938	9	19.5	43,022	5.8	.4
222	1106	2336	39	17.0	45,234	5.8	
223	1110	0034	43	19.0	45,880	5.8	
224	1019	0137	43	21.0	43,801	7.7	
225	1005	0242	43	20.5	43,900	7.8	

STATION 15 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1105	0847	7	15.5	44,550	7.4	
175	1210	1030	15	16.5	45,860	7.5	.4
176	1152	1123	9	15.0	45,810	7.6	.8
177	1239	1217	43	16.0	44,800	7.8	1.2
180	1123	0223	2	17.5	45,673	6.7	.2
182	1056	0408	23	16.5	45,981	6.8	.4
183	1129	0457	930	17.0	45,342	6.8	.3
184	1130	0545	43	19.5	43,780	8.0	1.7
187	1200	0757	14	17.5	45,000	6.0	.2
188	1046	0837	4	17.0	46,360	6.4	
189	1052	0920	4	19.0	45,673	6.5	
190	1046	1000	2	17.5	47,311	6.4	.2
191	1047	1040	23	17.5	46,010	6.5	
194	0908	0053	14	18.0	46,161	6.3	
195	0912	0155	10	18.0	45,943	6.4	
196	0954	0257	19	17.5	46,161	6.1	
197	0914	0400		18.0	44,030	5.8	.4
198	1052	0456	430	19.5	43,440	5.7	
201	1042	0736	9	19.0	44,230	6.2	
202	1031	0826	4	19.0	45,900	6.6	
203	1043	0914	240	18.5	44,230	6.4	
204	1040	1000	9	20.0		6.3	.2
205	1057	1049	9	20.2	44,230	6.8	
205	1057	1049	23	20.2		6.8	
206	1059	2310	9	18.0	44,531	6.0	
209	1204	0144	1	18.5	46,114	5.8	
210	1057	0240	9	17.0	45,900	5.4	
211	1105	0335	9	18.0	45,140	5.4	.2
214	1046	0604	43	16.0	45,660	5.0	
215	1036	0648	4	16.5	46,095	5.5	
217	1042	0812	7	15.5	45,880	6.2	
218	1442	0854	15	18.0	45,553	5.5	.2
219	1308	0938	4	17.0	46,244	5.6	.2
222	1106	2336	9	16.5	45,880	5.8	
223	1110	0034	21	17.0	46,095	5.7	
224	1019	0137	43	18.5	45,880	5.3	
225	1005	0242	93	19.0	45,400	5.2	

STATION 16 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1120	0850	2	17.5	43,300	8.5	1.4
175	1228	1010	43	20.0	41,400	8.9	2.8
176	1208	1120	75	17.0	42,830	8.1	1.8
177	1254	1220	43	18.5	43,200	8.9	3.1
180	1137	0300	4	20.5	42,864	6.9	1.0
182	1112	0400	430	20.0	40,290	7.8	4.0
183	1144	0440	93	20.0	43,200	7.7	2.8
184	1147	0550	430	21.5	42,080	9.7	2.9
187	1215	0730	43	20.5	43,671	7.7	2.5
188	1102	0840	240	21.0	42,770	7.8	
189	1107	0930	93	22.0	43,423	7.7	
190	1102	0950	4	21.0	42,553	7.7	2.0
191	1100	1100	9	21.0	43,983	8.2	
194	0854	0110	49	20.0	42,910	7.8	
195	0859	0150		20.5	42,350	7.8	
196	0940	0300		20.5	39,400		
197	0902	0350		19.0	39,080	6.2	2.2
198	1107	0500	430	21.0	40,542	9.7	
201	1100	0740	230	22.0	41,581	8.6	
202	1047	0820	430	21.5	43,830	7.9	
203	1059	0920	39	22.0	45,681	7.2	
203	1059	0920	43	22.0		7.2	
204	1055	1010	93	23.5	42,121	8.3	3.0
205	1112	1110	75	23.8	42,304	8.6	
206	1112	2340	23	21.5	42,863	8.0	
209	1210	0210	2	24.5	40,510	9.2	
210	1110	0300	43	23.5	40,882	7.9	
211	1118	0410	23	24.0	41,282	7.4	1.8
214	1103	0630	93	20.0	39,835	8.1	
215	1052	0700	43	21.5	40,844	7.2	
217	1059	0700	43	18.5	43,022	6.2	
218	1451	0800	43	20.0	41,905	5.9	1.6
219	1251	0840	23	20.0	43,022	5.9	.7
222	1117	2230	43	19.0	45,234	5.6	
223	1120	0030	43	20.0	44,000	6.1	
224	1030	0137	93	22.0	43,801	6.8	
225	1015	0242	9	21.0	43,800	8.0	

STATION 16 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1120	0850	23	16.5	44,300	8.2	.9
175	1228	1010	9	17.5	43,990	7.7	1.1
176	1208	1120	7	15.0	45,490	7.3	.2
177	1254	1220	23	16.5	45,450	7.0	.2
180	1137	0300	2	18.0	45,555	6.2	.3
182	1112	0400	7	17.0	45,880	6.2	.1
183	1144	0440	93	18.0	46,083	6.1	.3
184	1147	0550	23	19.0	45,380	5.8	
187	1215	0730	4	19.0	44,310	6.0	.3
188	1102	0840	4	18.5	46,000	6.1	
189	1107	0930	7	20.0	45,905	6.0	
190	1102	0950	2	19.0	46,171	6.1	.2
190	1102	0950	4	19.0		6.1	
191	1100	1100	2	19.0	45,973	6.1	
194	0854	0110	12	19.0	44,885	5.6	
195	0859	0150	8	19.0	44,273	5.9	
196	0940	0300		18.0	44,300	5.9	
197	0902	0350	49	17.0	44,633	5.6	.3
198	1107	0500	750	19.0	44,230	5.7	
201	1100	0740	43	21.0	42,323	6.5	
202	1047	0820	4	20.0	31,290	5.9	
203	1059	0920	15	20.0	44,230	6.0	
204	1055	1010	21	20.0	44,430	6.0	.2
205	1112	1110	75	20.6	44,330	6.1	
205	1100	1100	23	20.6		6.1	
206	1112	2340		19.0	44,330	6.2	
209	1218	0210	9	18.0	46,333	5.4	
210	1110	0300	4	17.0	45,900	5.0	
211	1118	0410	9	20.0	43,910	4.4	.3
214	1103	0630	7	16.0	45,880	4.6	
215	1052	0700	9	17.0		5.4	
217	1059	0700	4	16.5	45,880	4.8	
217	1059	0700	2	16.5			
218	1457	0800	43	18.5	44,000	4.8	.1
219	1251	0840	9	17.5	45,023	5.2	.2
222	1117	2230	23	18.0	44,404	5.4	
223	1120	0030	9	18.5	45,880	5.3	
224	1030	0137	43	19.0	44,201	5.1	
225	1015	0242	9	20.0	44,400	5.0	

STATION 17 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIME OF TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1138	0850	36	18.0	42,000	8.9	2.0
175	1249	1010	43	20.5	40,240	9.3	5.1
176	1226	1120	120	17.0	42,710	8.2	2.6
177	1317	1220	430	19.5	40,770	8.4	2.8
180	1156	0300	150	21.0	41,180	8.5	6.5
182	1128	0400	230	20.0	39,360		2.7
183	1202	0440	240	21.0	40,607	8.0	2.4
184	1203	0550	430	22.0	39,530	9.6	3.9
187	1233	0730	150	20.5	41,452	8.6	3.1
188	1120	0840	93	23.0	42,790	8.9	
189	1127	0930	43	23.0	41,560	9.7	
190	1120	0950	23	22.0	42,773	8.4	2.7
191	1117	1100	240	21.5	43,480	8.0	
194	0836	0110	2,400	21.5	41,624	7.4	
195	0840	0150	230	21.0	44,680	7.4	
196	0924	0300	1,100	20.5	35,600		
197	0845	0350	2,400	19.0	38,920	5.5	1.3
198	1123	0500	430	22.0	40,373	6.6	
201	1120	0740	230	23.5	39,393	11.3	
202	1114	0820	93	23.5	40,541	8.3	
203	1116	0920	93	24.0		9.6	
203	1116	0920	93	24.0	38,645	9.6	
204	1113	1010	9	25.5	46,373	9.9	5.5
205	1128	1110	93	24.2	44,130	8.3	
206	1129	2340	39	23.0	40,542	8.7	
209	1234	0210	23	25.0	40,041	9.4	
210	1130	0300	23	25.0	39,234	9.5	
211	1135	0410	240	25.5	38,795	8.7	4.5
214	1121	0630	460	22.0	38,875	9.2	
215	1112	0700	1,100	21.5	38,800	7.4	
217	1118	0700	43	19.0	41,905	6.0	
218	1514	0800	460	21.0	42,090	6.0	1.4
219	1240	0840	23	21.0	42,832	5.7	.7
222	1134	2230	240	19.0	43,801	6.0	
223	1134	0030	210	20.5	42,460	6.8	
224	1045	0137	240	24.0	42,460	6.5	
225	1027	0242	21	22.0	43,800	7.2	

STATION 17 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIME OF TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1138	0850	20	17.0	43,700	7.6	.2
175	1249	1010	4	17.5	44,640	7.4	.3
176	1226	1120	23	16.0	45,090	7.4	.3
177	1317	1220	9	17.5	45,020	6.8	.2
180	1156	0300	2	18.5	44,714	6.6	
182	1128	0400	2,400	17.0	45,177	5.7	
183	1202	0440	43	18.5	45,180	5.4	.2
184	1203	0550	75	19.0	45,170	5.0	.2
187	1233	0730	23	19.0	43,617	6.2	.7
188	1120	0840	9	19.0	44,620	5.9	
189	1127	0930	4	20.5	45,590	5.8	
190	1120	0950	3	20.0	45,860	6.2	.3
191	1117	1100	4	20.0	44,781	6.3	
194	0836	0110	15	19.5	44,680	5.7	
195	0840	0150	4	19.0	37,320	5.2	
196	0924	0300	43	18.0	44,000	5.4	
197	0845	0350	240	18.0	44,430	5.3	.5
198	1123	0500	150	20.0	43,830	4.8	
201	1120	0740	23	21.0	43,632	6.0	
202	1114	0820	23	21.5	44,030	6.0	
203	1116	0920	9	21.0	43,830	6.0	
204	1113	1010	23	22.5	44,030	6.1	.4
205	1128	1110	15	22.0	46,333	5.9	
205	1128	1110	15	22.0		5.9	
206	1129	2340	2	20.0	44,230	5.7	
209	1234	0210	4	20.0	45,046	4.7	
210	1130	0300	9	20.0	45,470	4.4	
211	1135	0410	9	20.0	44,520	4.2	.5
214	1121	0630	15	18.0	45,450	4.7	
215	1112	0700	23	17.5	45,023	4.0	
217	1118	0700	15	17.0	44,201	4.9	
217	1118	0700	9	17.0			
218	1514	0800	9	18.5	45,023	5.0	.4
219	1240	0840	4	18.0	44,000	5.0	.4
222	1134	2230	9	18.0	44,404	5.0	
223	1134	0030	93	18.5	45,450	4.9	
224	1045	0137	43	20.0	44,201	4.6	
225	1027	0242	4	20.0	44,400	4.0	

STATION 18 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1150	0850	43	17.5	43,300	9.2	1.8
175	1302	1040	230	19.5	40,820	9.8	4.4
176	1238	1134	230	17.0	42,740	8.4	2.8
180	1207	0235	43	19.5	41,726	7.6	
182	1139	0418	23	20.0	41,255	8.8	4.3
183	1213	0508	430	18.4	43,050	8.0	3.5
184	1215	0555	930	22.0	41,250	10.2	4.2
187	1246	0806	43	20.0	43,263	8.2	3.4
188	1131	0847	240	21.5	41,730	9.8	
189	1139	0930	240	23.0	42,155	10.9	
190	1133	1010	23	21.0	43,783	8.8	3.9
191	1128	1100	240	20.5	44,254	7.0	
194	0824	0100	240	21.0	42,164	7.8	
195	0828	0205	430	21.0	40,924		
196	0912	0310		20.0	41,200		
197	0833	0410	2,400	19.0	40,711	6.1	1.8
198	1124	0506	430	20.5	42,304	7.3	
201	1132	0746	430	22.5	42,121	10.4	
202	1124	0836	230	23.0	41,940	10.7	
203	1128	0924	460	22.5	42,121	8.3	
203	1128	9999	43	22.5		8.3	
204	1125	1010	460	23.0	40,542	7.9	2.7
205	1141	1100	93	24.0	42,304	7.2	
206	1140	2319	93	22.0	40,711	8.3	
209	1247	0153	9	24.0	45,681	10.3	
210	1140	0249	120	24.5	39,393	10.0	
211	1147	0343	43	24.0	39,920	8.6	4.6
214	1132	0613	240	21.0	39,510	7.2	
215	1123	0657	93	21.0	40,333	7.8	
217	1130	0821	240	18.5	42,363	5.3	
218	1525	0901	460	19.5	43,022	5.0	.4
219	1230	0947	43	21.0	43,410	5.8	1.1
222	1145	2345	240	19.5	43,410	5.7	
223	1141	0043	210	20.0	44,000	5.1	
224	1055	0146	93	22.0	43,801	7.5	
225	1037	0251	4	20.0	44,000	6.8	

STATION 18 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1150	0850	9	16.5	44,100	8.0	.8
175	1302	1040	93	17.5	43,580	7.4	.4
176	1238	1134	23	16.5	44,500	7.2	.5
180	1207	0235	43	17.5	44,800	6.0	.3
182	1139	0418	430	17.5	44,661	5.8	.5
183	1213	0508	93	18.5	44,560	6.7	1.3
184	1215	0556	93	19.0	43,910	5.7	.4
187	1246	0806	43	19.5	44,372	6.1	.7
188	1131	0847	43	20.0	44,090	6.0	
189	1139	0930	23	20.5	43,022	5.9	
190	1133	1010	93	20.0	43,320	6.5	1.0
191	1128	1100	75	20.0	44,280	6.2	
194	0824	0100	150	20.0	43,680	5.8	
195	0828	0205	43	20.6	43,100	6.1	
196	0912	0310	15	19.0	44,600	5.6	
197	0833	0410	150	18.0	44,230	5.3	.3
198	1134	0506	430	20.0	42,675	5.8	
201	1132	0746	93	21.0	33,494	5.8	
202	1124	0836	93	22.0	43,244	5.7	
203	1128	0924	23	21.0	42,675	5.8	
204	1125	1010	23	22.0	42,304	5.7	.4
205	1141	1100	23	22.5	43,244	5.7	
205	1100	1100	43	22.5		5.7	
206	1140	2319	93	20.5	42,490	5.7	
209	1247	0153	9	20.0	44,230	4.4	
210	1140	0249	93	20.0	44,190	4.3	
211	1147	0343	23	20.0	44,300	4.3	.6
214	1132	0613		18.0	44,000	4.1	
215	1123	0657	9	18.0	44,000	4.4	
217	1130	0821	15	17.5	43,801	4.8	
217	1130	0821	9	17.5			
218	1525	0901	460	19.0	43,801	4.8	.4
219	1230	0947	23	19.0	43,604	4.9	.5
222	1145	2345	240	19.0	44,000	4.8	
223	1141	0043	240	19.5	44,201	4.9	
224	1055	0146	43	20.0	44,000	4.5	
225	1037	0251	43	21.0	44,400	5.4	

STATION 19 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1218	0850	930	18.0	39,800	6.9	2.3
175	1330	1030	930	20.5	40,360	7.6	3.6
176	1305	1120		17.5	38,100	7.8	6.1
180	1233	0300	72	22.5	39,292	7.2	2.1
182	1205	0450	2,300	19.0	39,391	6.0	4.5
183	1239	0515	430	21.0	40,322	7.0	3.7
184	1242	0600	750	21.5	40,670	6.2	
187	1310	0806	1,500	21.5	38,855	7.0	2.3
188	1159	0840	4,300	22.5	39,790	9.4	
189	1208	0930	4,300	24.0	38,533	10.0	
190	1200	1000	930	23.0	40,720	9.9	11.0
191	1140	1100	230	22.0	41,910	8.4	
194	0758	0110	4,300	21.0	38,500	5.3	
195	0800	0200	2,400	22.0	31,830	5.1	
196	0847	0250	4,300	20.0	38,500	4.8	
197	0808	0400	46,000	19.0	36,000	4.5	
198	1200	0505	4,300	23.0	36,720	5.2	
201	1159	0750	2,300	23.0	42,490	5.6	
202	1150	0830	4,300	23.5	35,904	6.4	
203	1154	0920	7,500	24.0	35,641	6.3	
203	1154	0920	1,100	24.0		6.3	
204	1151	1010	240	26.0	36,040	9.3	6.0
205	1212	1100	15	25.3	36,040	9.0	
206	1207	1200	23	24.0	37,140	7.5	
209	1313	0210	7,500	26.0	36,306	11.3	
210	1205	0240	46,000	27.0	34,750	10.3	
211	1213	0400	2,300	27.0	34,014	9.2	5.4
214	1159	0620	30	20.0	36,390	5.2	
215	1150	0700	2,300	21.5	38,643	4.6	
217	1158	0820	4,300	18.5	40,333	5.0	
218	1549	0900	93	20.0	42,090	4.6	.3
219	1207	0940	2,400	20.5	42,090	4.7	1.1
222	1207	1200	2,300	19.5	42,090	4.9	
223	1205	0030	2,300	21.0	42,271	5.2	
224	1115	0110	430	23.5	42,050	6.4	
225	1057	0220	930	23.0	42,000	6.2	

STATION 19 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1218	0850	20	20.5	42,800	6.3	.5
175	1330	1030	75	18.5	43,250	7.3	.6
176	1305	1120	39	16.5	42,830	6.5	.5
180	1233	0300	43	19.5	44,481	5.7	
182	1205	0450	21	17.0	44,750	5.3	.3
183	1239	0515	93	18.5	44,890	5.0	.2
184	1242	0600	430	19.0	44,880	5.0	.4
187	1310	0806	23	20.0	43,880	5.5	.8
188	1159	0840	93	20.0	43,460	4.8	
189	1208	0930	43	21.0	45,364	4.8	
190	1200	1000	23	20.5	43,691	4.6	.3
191	1140	1100	43	20.5	43,234	4.7	
194	0758	0110	150	19.5	44,273	5.1	
195	0800	0200	460	19.5	43,290	4.4	
196	0847	0250	240	18.0	45,200	5.0	
197	0808	0400	90	18.0	42,490	5.1	
198	1200	0505	93	20.5	44,270	4.5	
201	1159	0750	43	21.0	42,490	5.4	
202	1150	0830	93	22.0	43,053	5.0	
203	1154	0920	93	22.0	42,304	4.8	
204	1151	1010	43	23.0		4.9	.1
205	1212	1100	230	23.0	42,270	5.0	
205	1212	1100	930	23.0		5.0	
206	1207	1200	460	22.0	41,230	4.6	
209	1313	0210	75	22.0	44,030	3.5	
210	1205	0240	1,100	21.0	44,030	3.0	
211	1213	0400	1,100	22.0	40,590	4.0	.9
214	1159	0620	93	18.0	44,610	3.4	
215	1150	0700	21	18.5	44,815	4.2	
217	1158	0820	9	17.0	44,000	3.4	
218	1549	0900	23	18.0	44,000	4.4	.4
219	1207	0940	73	18.5	43,801	4.3	.5
222	1207	1200	2,300	19.0	44,000	4.8	
223	1205	0030	91	19.5	44,404	4.6	
224	1115	0110	36	21.5	43,410	4.0	
225	1057	0220	36	21.5	44,400	3.2	

STATION 20 TOP

	TIME OF						
YEAR (DAYS) (1)	DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1115	0845		19.0	35,800	3.4	
174	0750	2130		19.0	34,630	2.9	
174	1215	0930		21.5	33,290	2.9	
175	0633	2215		17.5	34,060	2.2	
175	1119	1030		19.2	36,020	2.4	
176	0626	2315		18.0	36,110	1.7	
176	1200	1130		16.5	34,950	3.4	
177	0827	2346		17.8	30,860	1.7	
177	1407	1221		18.0	34,530	1.2	
180	0646	0227		17.1	32,630	2.8	
180	1047	0227		18.2	35,310	2.6	
181	0648	0320		20.7	33,740	3.2	
181	1051	0320		21.0	31,860	3.0	
182	1108	0445		18.0	35,590	3.0	
182	0658	0445		16.8	39,961	2.7	
183	0712	0530		18.8	34,180	7.6	
183	1116	0530		20.7	33,800	7.0	
184	0649	0600		18.4	34,770	3.4	
184	1105	0600		21.0	37,500	5.4	
187	0656	2000		20.2	37,120	8.6	
187	1116	0800		20.4	34,770	7.7	
188	1104	0820		20.8	33,540	8.7	
188	0656	2030		20.5	33,750	7.3	
189	0651	2150		19.4	34,180	4.2	
189	1052	0915		20.4	38,660	4.5	
190	0655	2120		19.8	37,037	5.0	
190	1054	0955		21.8	37,214	8.1	
191	0653	2330		21.0	37,736	6.1	
191	1045	1040		22.0	23,872	9.8	
194	0720	0120		20.1	38,413	3.2	
194	1106	0120		22.8	25,835	9.5	
195	0650	0130		22.0	26,324	6.1	
195	1133	0130		21.8	24,974	6.1	
196	0758	0230		19.7	25,605	2.4	
196	1231	0230		19.4	27,721	2.5	
197	1156	0330		19.2	28,370	2.3	
197	0649	0330		18.3	32,470	2.0	
198	0801	0440		20.0	29,440	2.7	

STATION 20 TOP

	TIME OF						
YEAR (DAYS) (1)	DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
198	1212	0440		20.8	27,721	3.2	
201	0652	1920		22.2	24,885	4.0	
201	1125	0725		23.1	24,633	3.9	
203	0647	2115		22.8	21,152	3.4	
203	1147	0930		23.9	25,880	3.6	
204	0847	2215		23.6	20,484	4.3	
204	1442	1015		23.9	20,702	5.1	
205	0732	2315		23.3	19,270	4.6	
205	1348	1115		23.8	26,370	2.8	
206	0647	2400		22.7	21,670	2.9	
206	1134	2400		23.9	19,305	4.2	
209	1153	0230		24.9		5.9	
209	0646	0230		22.4	22,265	3.6	
210	0651	0315		23.6	27,642	8.6	
210	1204	0315		25.6	26,086	13.7	
211	0655	0415		24.2	28,103	9.2	
211	1202	0415		25.2	24,271	14.0	
214	0656	0600		20.3	29,244	4.3	
214	1125	0600		21.7	35,590	3.0	
215	0707	1900		19.2	34,571	2.9	
216	0655	1930		19.5	38,720	3.8	
216	1218	0730		22.0	33,380	7.5	
217	0652	2000		19.[illegible]	34,571	6.2	
217	1233	0830		19.8	37,520	6.4	
218	1006	0930		22.0	33,380	3.0	
218	1342	0930		22.2	34,450	3.3	
219	1016	0945		21.0	37,090	2.7	
219	1353	0945		21.8	35,720	3.4	
222	1217	1210		21.0	37,231	2.3	
222	0738			21.0	32,270	1.7	
223	1152	0045		23.5	36,810	5.2	
223	0742	0045		21.7	37,231	2.4	
224	1138	0130		24.6	34,820	2.5	
224	0659	0130		21.6	40,333	1.2	
225	0724	0245		22.8	33,495	2.2	
225	1210	0245		24.5	35,460	3.6	

STATION 20 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1115	0845		17.0	43,500	1.9	
174	0752	2130		18.0	41,560	3.3	
174	1217	0930		17.0	43,020	2.5	
175	0635	2215		17.0	35,140	2.4	
175	1123	1030		16.5	42,720	4.7	
176	0628	2315		15.2	43,690	2.0	
176	1202	1130		16.5	42,500	3.1	
177	1409	1221		16.0	42,500	3.4	
177	0828	2346		15.9	42,551	3.4	
180	0649	0227		15.6	43,800	3.4	
180	1049	0227		15.7	41,530	3.1	
181	0650	0320		16.4	44,454	1.9	
181	1053	0320		16.4	45,070	2.8	
182	1110	0445		15.2	44,200	3.5	
182	0659	0445		16.6	44,195	2.9	
183	0713	0530		16.0	43,432	2.5	
183	1118	0530		18.2	42,050	2.2	
184	0651	0600		15.4	44,190	3.0	
184	1108	0600		16.6	45,070	2.9	
187	0658	2000		16.0	43,380	1.0	
187	1119	0800		16.7	43,100	.5	
188	1108	0820		16.4	44,190	.7	
186	0658	2030		16.4	44,390	.4	
189	0653	2150		17.0	43,534	2.7	
189	1053	0915		17.9	43,405	2.8	
190	1056	0955		18.0	44,230	2.1	
190	0658	2120		17.3	43,103	1.8	
191	0656	2330		18.2	42,920	1.5	
191	1047	1040		17.9	41,983	.8	
194	0722	0120		18.4	43,604	2.2	
194	1108	0120		19.2	42,164	1.0	
195	0652	0130		18.5	41,271	.9	
195	1135	0130		19.3	43,874	1.6	
196	0759	0230		18.2	42,863	2.4	
196	1233	0230		18.2	42,490	2.9	
197	0651	0330		17.3	42,533	3.1	
197	1158	0330		18.2	43,244	2.9	
198	0803	0440		18.0	36,720	2.4	

STATION 20 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
198	1215	0440		18.5	42,121	2.1	
201	0654	1920		19.1	42,304	1.2	
201	1127	0725		20.0	42,304	.7	
203	0649	2115		19.7	40,542	.9	
203	1149	0930		20.4	40,711	.4	
204	1444	1015		20.1	40,542	.8	
204	0848	2215		20.3	40,373	2.6	
205	0733	2315		20.1	40,373	2.9	
205	1350	1115		20.3	41,940	2.8	
206	0649	2400		20.4	38,920	2.2	
206	1136	2400		20.0	40,711	2.8	
209	1155	0230		20.1		1.3	
209	0648	0230		19.6	42,121	2.0	
210	0653	0315		19.8	43,632	1.2	
210	1205	0315		20.4	43,244	1.4	
211	1203	0415		20.3	42,000	1.4	
211	0657	0415		19.6	42,522	1.4	
214	1127	0600		18.2	44,201	1.5	
214	0658	0600		18.0	43,604	1.4	
215	0709	1900		16.6	45,023	2.0	
215	1133	0710		18.6	44,000	1.3	
216	0657	1930		17.7	44,404	1.8	
216	1220	0730		20.8	43,311	1.2	
217	0654	2000		17.9	44,000	1.0	
217	1235	0830		17.4	44,100	.3	
218	1008	0930		19.4	42,090	.7	
218	1344	0930		19.8	43,320	.3	
219	1017	0945		19.1	42,271	2.6	
219	1355	0945		19.6	42,460	.8	
222	1217	1210		20.0	42,271	2.4	
222	0740			19.8	42,090	1.5	
223	1153	0045		20.9	43,022	2.8	
223	0744	0045		20.2	42,460	2.2	
224	1140	0130		21.2	42,460	2.4	
224	0700	0130		19.9	42,832	2.1	
225	0725	0245		20.7	43,022	2.1	
225	1213	0245		20.6	43,801	2.1	

STATION 21 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1125	0845		18.0	35,800	3.4	7.2
174	0807	2130		18.0	35,140	2.2	8.0
174	1230	0930		21.0	34,440	2.7	
175	0648	2215		17.0	34,270	2.1	4.4
175	1135	1030		20.0	34,930	2.2	
176	0641	2315		18.6	34,450	1.6	4.1
176	1215	1130		18.1	33,180	2.8	
177	0850	2346		18.1	30,060	1.9	4.5
177	1353	1221		19.3	32,210	1.2	
180	0702	0227		17.3	35,720	1.8	2.6
180	1103	0227		19.0	31,800	2.2	
181	0708	0320		20.0	34,630	1.8	3.8
181	1109	0320		20.8	34,650	2.3	
182	1122	0445		18.6	31,850	2.6	
182	0718	0445		16.5	36,540	2.6	3.3
183	0719	0530		18.3	35,210	6.2	4.3
183	1132	0530		20.0	33,270	4.3	
184	0713	0600		17.9	36,060	2.4	7.4
184	1120	0600		18.9	33,993	2.4	
187	0705	2000		20.1	35,480	7.3	5.4
187	1130	0800		20.2	35,970	1.0	
188	1120	0820		20.8	36,480	7.5	
188	0712	2030		20.2	33,090	6.3	7.1
189	0704	2150		19.6	34,950	4.0	4.0
189	1105	0915		20.7	36,884	5.1	
190	0709	2120		19.8	36,630	4.6	3.3
190	1105	0955		21.5	38,540	6.6	
191	0703	2330		21.0	36,570	4.8	6.5
191	1054	1040		21.9	25,103	9.4	
194	0733	0120		20.7	38,413	3.9	5.6
194	1116	0120		22.2	26,183	7.6	
195	0703	0130		21.3	25,103	5.6	4.6
195	1151	0130		21.7	28,990	3.9	
196	1245	0230		20.0	23,703	3.2	
196	0823	0230		20.0	22,523	2.7	5.4
197	0702	0330		18.5	33,702	2.0	5.0
197	1210	0330		19.8	32,112	2.1	
198	0814	0440		20.0	27,486	3.0	10.2
198	1224	0440		21.2	25,273	3.3	
201	0711	1920		21.9	24,633	3.5	2.4
201	1141	0725		23.1	27,880	4.2	

STATION 21 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	0704	2115		22.9	19,460	3.7	4.6
203	1159	0930		23.8	23,732	3.9	
204	0913	2215		24.6	16,981	4.6	
204	1415	1015		24.4	21,622	5.0	
205	0748	2315		23.6	18,090	4.2	3.2
205	1331	1115		24.4	19,270	4.7	
206	0703	2400		23.7	19,080	3.8	3.4
206	1202	2400		23.8	23,731	3.7	
209	1205	0230		24.0	26,226	4.4	
209	0702	0230		22.3	28,203	2.7	2.6
210	0708	0315		22.8	25,273	3.3	2.5
210	1217	0315		25.6	25,605	10.5	
211	0710	0415		24.6	27,170	7.5	4.6
211	1215	0415		25.2	25,970	11.9	
214	0712	0600		20.0	39,032	3.2	2.2
214	1137	0600		20.6	29,245	2.5	
215	0720	0710		18.7	36,950	3.4	2.4
215	1143	0710		21.0	37,090	2.9	
216	0708	1930		19.3	35,852	4.2	2.4
216	1229	0730		23.4	37,374	8.4	
217	0707	2000		20.0		5.4	3.9
217	1256	0830		19.7	36,530	4.2	
218	1019	0930		21.3	36,950	3.6	2.9
218	1353	0930		22.0	35,985	2.7	
219	1029	0945		21.0	38,720	3.1	2.2
219	1406	0945		22.1	39,032	3.0	
222	0758			19.9	35,852	1.4	2.0
222	1231	1210		21.2	35,852	2.6	
223	1203	0045		23.3	36,810	2.9	
223	0752	0045		21.8	37,231	1.7	2.4
224	1150	0130		24.9	35,720	2.7	
224	0713	0130		21.7	36,530	2.6	2.3
225	0736	0245		22.7	36,950	2.5	
225	1222	0245		24.4	35,720	2.9	
237	0753	0050		27.2	35,590	1.6	
238	0700	0130		23.0	35,450	1.4	
240	0658	0310		25.6	35,590	6.8	
243	0721	0550		24.0	31,030	5.2	
244	0722	0630		24.7	24,760	3.1	
245	0730	0705		24.9	26,300	3.0	
246	0654	1930		25.0	24,630	2.6	5.8

STATION 21 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
247	0658	2015		24.9	26,740	3.4	
251	0750	2319		24.2	31,200	2.2	
252	0654	0019		24.9	31,630	1.7	
253	1243	0123		25.5	34,330	3.4	2.8
254	0927	0229		24.2	34,200	1.7	

STATION 21 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1125	0845		16.0	43,000	2.1	7.6
174	0811	2130		16.0	42,000	2.5	7.7
174	1232	0930		17.5	42,420	2.3	
175	0650	2215		15.5	42,120	1.7	2.4
175	1138	1030		16.1	42,460	2.0	
176	0643	2315		17.8	33,979	1.7	6.7
176	1217	1130		15.2	42,800	1.6	
177	1356	1221		16.0	42,480	1.4	
177	0852	2346		15.8	41,610	1.8	2.8
180	0704	0227		15.1	43,030	4.0	2.2
180	1105	0227		15.4	43,530	1.6	
181	0710	0320		17.1	42,795	2.6	2.0
181	1111	0320		16.7	44,414	2.6	
182	1124	0445		15.5	43,103	1.8	
183	0721	0530		16.1	43,620	2.5	1.4
182	0720	0445		15.0	43,432	2.5	3.8
183	1134	0530		16.7	43,880	2.3	
184	0716	0600		16.0	44,040	1.8	2.6
184	1122	0600		16.4	44,783	1.8	
187	0708	2000		16.9	43,100	1.7	3.5
187	1132	0800		16.5	43,640	.5	
188	1121	0820		16.2	43,290	.4	
188	0714	2030		17.0	42,800	1.0	2.7
189	0706	2150		16.7	42,500	1.1	2.3
189	1107	0915		17.1	43,391	.7	
190	0711	2120		17.3	43,670	1.2	1.7
190	1107	0955		16.9	44,340	1.8	
191	0705	2330		18.0	43,233	1.0	3.3
191	1056	1040		18.6	41,271	1.8	
194	0735	0120		18.9	42,643	1.9	2.0
194	1118	0120		18.7	43,290	.6	
195	0705	0130		18.5	42,164	.2	2.1
195	1153	0130		18.7	42,175	.5	
196	0825	0230		18.0	41,230	.6	1.7
196	1246	0230		18.2	41,404	1.2	
197	0704	0330		17.8	42,350	2.4	2.7
197	1212	0330		18.0	43,830	2.4	
198	0817	0440		18.1	42,304	1.9	2.2
198	1226	0440		18.4	42,490	1.3	
201	0713	1920		19.2	41,940	.9	1.4
201	1143	0725		19.2	41,581	.1	

STATION 21 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIME OF TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	0705	2115		20.4	38,920	1.8	3.8
203	1200	0930		20.1	39,000	1.4	
204	1416	1015		20.8	38,951	2.4	
204	0914	2215		20.6	38,920	1.5	
205	1332	1115		21.7	41,055	1.4	
205	0750	2315		22.0	38,920	1.7	1.8
206	0704	2400		19.8	40,542	1.9	1.6
206	1203	2400		20.1	40,373	1.9	
209	1207	0230		20.0	43,244	.9	
209	0704	0230		19.8	42,121	1.2	1.7
210	0709	0315		19.9	43,830	1.0	1.1
210	1219	0315		20.4	41,581	.8	
211	1217	0415		20.4	42,000	.6	
211	0712	0415		20.0	41,795	.8	1.8
214	1139	0600		18.3	43,603	.6	
214	0715	0600		18.0	43,801	1.0	1.5
215	0722	0710		17.0	43,801	1.2	2.0
215	1145	0710		19.1	44,201	1.1	
216	0709	1930		17.6	44,000	1.3	2.1
216	1230	0730		20.6	44,000	.5	
217	0709	2000		17.9		.4	1.6
217	1257	0830		17.8	44,000	.5	
218	1020	0930		19.6	43,022	.3	1.6
218	1355	0930		20.3	42,090	1.1	
219	1030	0945		19.3	43,604	1.1	.9
219	1407	0945		19.7	43,801	1.9	
222	0800			19.7	42,460	.2	1.0
222	1232	1210		19.7	42,090	.4	
223	1205	0045		20.8	42,271	.9	
223	0754	0045		20.0	42,090	2.0	2.1
224	1152	0130		21.1	42,090	2.0	
224	0715	0130		20.0	42,123	1.9	1.4
225	0737	0245		20.3	42,090	1.7	
225	1224	0245		21.2	42,460	1.9	
237	0756	0050		21.4	44,200	.9	
238	0702	0130		22.4	44,000		
240	0701	0310		21.9	45,020	.7	
243	0722	0550		21.2	45,450	1.0	
244	0724	0630		21.5	44,610		
245	0731	0705		21.5	44,000		
246	0658	1930		23.1	28,810	.6	5.1

STATION 21 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIME OF TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
247	0700	2015		21.6	44,000		
251	0753	2319		22.8	42,830		
252	0700	0019		23.1	43,410		
253	1244	0123		23.4	43,800		4.9
254	0928	0229		22.7	44,000		

STATION 22 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1140	0845		19.0	37,100	2.9	3.8
174	0829	2130		20.0	36,970	2.0	2.8
174	1240	0930		22.5	32,990	2.4	
175	1145	1030		20.8	35,820	2.0	
175	0714	2215		20.5	42,710	1.4	2.2
176	1224	1130		17.5	33,060	1.6	
176	0652	2315		20.4	33,470	1.1	4.2
177	0926	2346		18.3	30,240	1.4	3.0
177	1340	1221		20.1	31,200	1.6	
180	0731	0227		18.4	31,250	1.9	3.4
180	1120	0227		20.2	40,920	2.1	
181	0722	0320		22.4	29,880	1.2	5.3
181	1125	0320		24.0	33,265	1.4	
182	1133	0445		19.4	34,014	1.8	
182	0743	0445		17.9	31,990	1.8	5.3
183	0740	0530		17.5	33,490	4.3	3.9
183	1147	0530		22.4	33,230	1.2	
184	0737	0600		18.2	39,320	1.9	5.4
184	1132	0600		20.2	31,712	2.1	
187	0728	2000		21.2	36,090	6.1	4.7
187	1141	0800		20.9	36,215	7.4	
188	1135	0820		22.3	31,200	5.0	
188	0736	2030		21.1	36,490	4.1	5.3
189	0726	2150		19.9	31,840	3.0	2.6
189	1118	0915		21.3	38,244	4.2	
190	0732	2120		20.0	36,510	3.1	3.0
190	1116	0955		20.9	37,500	4.7	
191	0722	2330		21.7	35,960	4.0	4.6
191	1101	1040		22.1	20,812	7.7	
194	0756	0120		21.8	36,530	5.1	2.5
194	1125	0120		23.0	23,641	10.5	
195	0713	0130		22.3	19,441	5.5	3.0
195	1202	0130		22.4	20,166	7.2	
196	0904	0230		19.0	13,762	5.7	4.3
196	1256	0230		19.9	21,061	3.1	
197	0713	0330		18.9	23,246	4.3	3.7
197	1225	0330		20.0	24,821	4.5	
198	0826	0440		20.6	21,670	4.0	3.1
198	1233	0440		22.1	22,063	4.2	
201	0723	1920		22.2	27,030	2.9	2.8
201	1150	0725		24.0	24,633	4.1	

STATION 22 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	0715	2115		23.1	16,220	4.1	4.2
203	1208	0930		24.9	15,873	5.7	
204	0925	2215		24.3	19,382	4.4	
204	1352	1015		26.1	16,060	5.8	
204	1353	1015		23.7	34,940	2.3	
205	0807	2315		23.4	17,160	4.6	2.9
205	1319	1115		25.0	20,275	4.8	
206	0746	2400		23.7	16,533	3.8	2.7
206	1213	2400		24.0	22,894	3.7	
209	1214	0230		25.4	23,446	4.9	
209	0717	0230		22.7	21,574	3.9	1.8
210	0738	0315		23.8	19,780	4.2	3.9
210	1226	0315		26.0	23,910	7.7	
211	0730	0415		23.8	23,286	5.6	4.2
211	1225	0415		26.5	23,280	11.4	
214	1217	0600		22.0	31,330	3.4	
214	0738	0600		20.6	38,110	2.4	3.0
215	0740	0710		19.6	37,520	2.4	3.2
215	1154	0710		21.7	34,390	3.2	
216	0739	0730		20.7	37,231	3.7	6.1
216	1237	0730		24.1	37,231	4.4	
217	0737	2000		22.0		2.9	3.0
217	1309	0830		21.3	32,270	2.9	
218	1052	0930		19.1	38,720	1.6	3.5
218	1404	0930		24.2	35,720	2.6	
219	1058	0945		22.7	40,333	2.4	1.8
219	1428	0945		23.6	35,920	2.4	
222	0850			22.2	34,571	1.9	1.8
222	1242	1210		22.0	36,255	3.0	
223	1213	0045		24.4	36,670	2.2	
223	0802	0045		22.0	33,611	1.4	6.5
224	0723	0130		22.3	31,950	2.0	4.6
224	1158	0130		24.9	40,000	1.4	
225	0745	0245		23.0	34,450	1.5	
225	1231	0245		25.0	37,665	1.7	
237	0836	0050		25.0	36,950	1.3	
237	0837	0050		22.6	43,020	.8	
238	0746	0130		24.1	33,720	1.5	
239	0857	0200		25.2	34,000	5.8	7.2
240	0730	0310		25.4	28,810	4.1	
240	1445	0310		28.6	34,910		

STATION 22 TOP

	TIME OF						
YEAR (DAYS) (1)	DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
240	1505	0310		28.4	34,400		
240	1535	1530		28.1	35,170		
240	1605	1530		27.8	35,300		
240	1630	1530		27.8	35,690		
240	1700	1530		27.8	35,040		
240	1735	1530		27.8	35,170		
240	1000	1530		27.7	35,300		
240	1830	1530		27.7	35,300		
240	1900	1530		27.7	34,650		
240	1930	1530		27.5	32,530		
240	2000	1530		27.6	33,670		
240	2030	1530		27.5	32,640		
240	2100	1530		28.1	35,040		
240	2130	1530		27.6	35,430		
240	2200	1530		27.4	31,870		
240	2230	1530		28.0	33,500		
240	2300	1530		28.0	38,430		
240	2330	1530		27.1	34,160		
241		1530		27.1	34,280		
241	0030	1530		27.0	36,370		
241	0100	1530		27.1	35,430		
241	0130	1530		27.0	34,530		
241	0200	1530		26.9	17,300		
241	0230	1530		26.9	30,740		
241	0300	1530		27.0	36,510		
241	0335	1530		26.8	36,650		
241	0400	0400		26.7	36,800		
241	0430	0400		26.6	37,370		
241	0500	0400		26.8	35,300		
241	0530	0400		26.5	37,080		
241	0600	0400		26.2	37,820		
241	0630	0400		25.8	36,520		
241	0700	0400		25.6	32,790		
241	0730	0400		26.0	33,820		
241	0800	0400		26.1	32,350		
241	0830	0400		26.7	35,970		
241	0900	0400		26.6	39,350		
241	0930	0400		26.6	36,380		
241	1000	0400		26.8	37,660		

STATION 22 TOP

	TIME OF						
YEAR (DAYS) (1)	DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
241	1030	0400		26.4	37,950		
241	1100	0400		26.2	36,930		
241	1130	0400		26.4	36,380		
241	1200	0400		26.3	36,790		
241	1230	0400		26.6	37,800		
241	1300	0400		27.0	36,380		
241	1330	0400		27.1	34,680		
241	1400	0400		27.1	33,590		
241	1400	0400		27.1	35,570		
241	1500	0400		27.1	35,050		
241	1530	0400		23.4	34,430		
241	1600	0400		22.5	34,550		
241	1630	1620		23.4	41,550		
241	1700	1640		26.1	37,220		
241	1730	1640		26.4	34,430		
241	1755	1640		26.0	31,920		
241	1835	1640		25.8	29,940		
241	1900	1640		25.4	44,220		
241	1930	1640		25.1	28,550		
241	2000	1640		25.1	25,860		
241	2030	1640		25.5	30,900		
241	2100	1640		26.7	29,780		
241	2130	1640		25.5	28,050		
241	2200	1640		25.6	27,000		
241	2230	1640		26.0	30,440		
241	2300	1640		25.8	30,130		
241	2330	1640		25.6	31,710		
242		1640		26.0	35,500		
242	0030	1640		26.0	32,070		
242	0100	1640		25.6	31,440		
242	0130	1640		25.2	30,250		
242	0200	1640		25.6	34,410		
242	0230	1640		25.6	35,040		
242	0300	1640		25.6	34,290		
242	0330	1640		25.2	34,160		
242	0400	1640		25.5	34,410		
242	0430	1640		24.8	36,360		
242	0500	0500		25.3	32,210		
242	0530	0500		24.2	36,780		
242	0600	0500		24.3	36,640		
242	0630	0500		25.2	31,170		
242	0703	0500		24.6	35,500		
242	0730	0500		24.6	35,370		

STATION 22 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
242	0800	0500		24.6	34,480		
242	0830	0500		24.5	35,200		
242	0902	0500		24.5	32,590		
242	0932	0500		24.4	28,390		
242	1002	0500		24.5	31,430		
242	1030	0500		24.5	29,420		
242	1100	0500		24.5	25,410		
242	1130	0500		24.5	26,890		
242	1200	0500		24.4	35,200		
242	1230	0500		25.4	38,720		
242	1300	0500		25.5	36,670		
242	1330	0500		25.7	37,520		
242	1400	0500		25.8	37,090		
242	1430	0500		25.3	36,950		
242	1500	0500		24.5	35,460		
242	1530	0500		24.3	37,810		
242	1555	0500		24.4	35,850		
243	0752	0550		23.7	29,330	3.6	
244	0754	0630		24.9	27,740	3.2	
245	0806	0705		25.1	26,590	3.1	
246	0746	0740		25.4	27,040	3.6	5.7
247	0739	2015		22.8	43,020	.5	
251	0824	2319		25.3	36,310	1.0	
252	0734	0019		25.9	31,330	2.0	
253	1216	0123		26.6	37,520	1.8	2.4
254	0906	0229		24.0	33,730	2.0	

STATION 22 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1118	0227		16.6	28,900	1.5	
173	1140	0845		19.0	41,000	2.3	6.6
174	0832	2130		17.0	41,890	2.6	4.6
174	1242	0930		19.5	39,305	2.3	
175	1148	1030		23.8	41,620	2.6	
175	0717	2215		16.0	41,450	2.8	1.4
176	1226	1130		17.5	42,830	2.1	
176	0653	2315		15.8	42,290	2.2	4.3
177	1342	1221		16.8	41,450	2.6	
177	0929	2346		17.5	37,410	2.2	.5
180	0733	0227		18.8	36,390	1.8	2.4
181	0724	0320		19.4	39,720	1.4	1.5
181	1127	0320		17.8	42,360	2.3	
182	1135	0445		16.1	43,290	1.9	
182	0745	0445		15.8	43,150	2.0	2.2
183	0742	0530		19.0	36,730	2.4	2.8
183	1150	0530		17.2	43,530	.8	
184	0739	0600		16.8	42,380	.4	7.2
184	1134	0600		17.7	42,230	1.4	
187	0730	2000		19.8	37,250	6.1	3.0
187	1143	0800		20.5	36,470	6.0	
188	1137	0820		19.7	31,550	4.8	
188	0738	2030		18.4	40,880	3.6	2.2
189	0728	2150		17.5	43,233	1.4	1.4
189	1120	0915		18.5	41,970	2.6	
190	0733	2120		18.0	42,750	1.9	2.1
190	1118	0955		18.8	42,490	2.0	
191	0724	2330		20.8	39,210	2.9	3.4
191	1103	1040		20.0	37,900	2.1	
194	0758	0120		19.9	40,502	2.2	3.3
194	1127	0120		19.9	39,755	1.1	
195	0715	0130		22.1	31,830	3.0	3.4
195	1204	0130		19.9	41,450	1.9	
196	0906	0230		19.9	35,130	1.9	3.7
196	1257	0230		18.1	41,230	.8	
197	0715	0330		18.7	38,500	1.8	2.5
197	1227	0330		18.4	40,711	.4	
198	0828	0440		20.0	36,310	1.6	2.0
198	1235	0440		19.3	42,304	1.2	
201	0725	0725		20.0	38,160	2.0	1.6
201	1152	0725		23.6	32,651	2.0	

STATION 22 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	0717	2115		20.0	38,920	1.0	2.2
203	1209	0930		23.8	33,670	2.1	
204	0926	2215		21.0	38,611	1.5	2.4
205	0809	2315		20.2	38,460	1.3	1.2
205	1321	1115		21.2	38,920	1.6	
206	0747	2400		20.6	37,423	1.4	2.4
206	1215	1215		20.6	38,920	1.1	
209	1216	0230		20.7	42,675	1.4	
209	0719	0230		21.8	37,000	2.1	2.0
210	0739	0315		21.4	40,711	1.2	1.7
210	1227	0315		22.1	37,570	1.1	
211	1226	0415		20.9	40,250	.3	
211	0728	0415		21.1	39,200	.8	6.0
214	0740	0600		18.3	43,410	.5	1.9
214	1219	0600		20.0	42,456	.4	
215	0740	0710		18.0	43,702	.2	1.6
215	1155	0710		19.1	43,214	.5	
216	0740	0730		19.2	42,090	.6	3.2
216	1239	0730		24.1	38,751	2.9	
217	0739	2000		19.6	44,000	.6	2.1
217	1311	0830		22.2	38,720	1.8	
218	1054	0930		21.7	40,333	2.2	1.9
218	1406	0930		23.8	36,530	2.1	
219	1059	0945		21.3	41,724	1.3	1.2
219	1430	0945		21.7	40,672	.9	
222	0851			20.6	41,724	.5	1.1
222	1243	1210		20.3	41,905	1.4	
223	1214	0045		21.0	42,123	.8	
223	0804	0045		20.9	40,333	1.2	3.4
224	1200	0130		21.1	42,460	1.6	
224	0725	0130		20.2	41,905	.9	1.2
225	0746	0245		20.8	42,090	1.3	
225	1232	0245		21.6	43,801	1.4	
238	0732	0130		22.6	44,000	1.0	
239	0858	0200		22.9	43,190	.2	1.6
240	0731	0310		21.1	44,400	.3	
240	1435	0310		21.6	42,740		
240	1500	0310		21.5	43,320		
240	1530	1530		21.6	43,320		
240	1600	1530		21.7	43,320		
240	1625	1530		21.7	43,320		

STATION 22 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
240	1655	1530		22.1	43,120		
240	1725	1530		21.5	43,520		
240	1755	1530		21.8	43,520		
240	1825	1530		21.8	43,520		
240	1900	1530		21.3	41,300		
240	1930	1530		21.8	43,120		
240	2000	1530		21.8	43,320		
240	2030	1530		21.9	42,930		
240	2100	1530		21.6	42,930		
240	2130	1530		21.4	43,720		
240	2200	1530		21.0	43,720		
240	2230	1530		21.2	43,520		
240	2300	1530		21.2	43,920		
240	2330	1530		21.2	44,950		
241		1530		21.3	43,520		
241	0030	1530		21.5	43,720		
241	0100	1530		21.4	43,720		
241	0130	1530		21.1	44,330		
241	0200	1530		20.8	44,740		
241	0230	1530		20.7	43,520		
241	0255	1530		20.8	44,741		
241	0330	1530		20.9	44,530		
241	0355	1530		20.9	44,950		
241	0425	0400		21.1	44,330		
241	0455	0400		21.6	43,520		
241	0525	0400		21.7	43,320		
241	0555	0400		21.7	43,120		
241	0625	0400		21.6	43,230		
241	0655	0400		21.7	43,620		
241	0725	0400		21.6	43,820		
241	0755	0400		23.8	36,930		
241	0825	0400		21.2	43,620		
241	0855	0400		21.6	44,020		
241	0925	0400		21.0	44,020		
241	0955	0400		20.9	44,220		
241	1025	0400		20.9	45,260		
241	1100	0400		20.8	44,220		
241	1130	0400		20.6	45,050		
241	1200	0400		20.6	44,840		
241	1230	0400		20.7	44,840		
241	1300	0400		20.6	43,230		

STATION 22 BOTTOM

TIME OF					SPEC.		
YEAR (DAYS) (1)	DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
241	1330	0400		20.7	43,820		
241	1400	0400		20.6	44,840		
241	1430	0400		20.6	44,020		
241	1455	0400		26.6	37,220		
241	1525	0400		24.9	34,820		
241	1555	0400		20.8	43,620		
241	1625	0400		21.0	43,820		
241	1655	1640		21.1	44,220		
241	1725	1640		21.1	43,040		
241	1750	1640		21.1	43,820		
241	1830	1640		21.7	43,820		
241	1855	1640		21.2	43,820		
241	1925	1640		21.7	42,760		
241	1955	1640		21.8	43,140		
241	2025	1640		21.5	42,760		
241	2055	1640		22.2	28,780		
241	2125	1640		21.1	43,330		
241	2155	1640		21.0	43,820		
241	2225	1640		20.5	43,820		
241	2300	1640		20.6	44,740		
241	2330	1640		20.5	43,930		
242		1640		20.5	45,760		
242	0030	1640		20.5	44,540		
242	0100	1640		20.5	44,540		
242	0130	1640		20.5	45,380		
242	0200	1640		20.5	44,040		
242	0230	1640		20.4	44,440		
242	0255	1640		20.4	45,810		
242	0325	1640		20.4	43,640		
242	0400	1640		20.5	44,650		
242	0425	1640		20.6	44,040		
242	0455	1640		20.6	44,860		
242	0525	0500		21.8	43,730		
242	0555	0500		21.1	44,040		
242	0625	0500		21.1	43,640		
242	0658	0500		21.2	44,040		
242	0724	0500		21.3	44,040		
242	0756	0500		21.1	43,840		
242	0825	0500		21.6	43,600		
242	0858	0500		21.5	43,410		
242	0927	0500		21.1	42,460		

STATION 22 BOTTOM

TIME OF					SPEC.		
YEAR (DAYS) (1)	DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
242	0957	0500		21.2	44,200		
242	1025	0500		21.3	42,830		
242	1100	0500		20.4	44,200		
242	1130	0500		20.4	44,610		
242	1200	0500		20.4	44,400		
242	1230	0500		20.4	45,230		
242	1300	0500		20.4	45,450		
242	1330	0500		20.4	44,400		
242	1400	0500		20.4	45,450		
242	1430	0500		20.3	45,660		
242	1455	0500		21.4	45,660		
242	1530	0500		20.4	44,810		
242	1550	0500		20.3	44,610		
243	0753	0550		21.6	43,600		
244	0755	0630		23.6	36,120		
245	0807	0705		23.2	31,230		
246	0747	0740		23.8	40,670	.9	2.5
247	0740	2015		22.8	43,020	.5	
251	0826	2319		23.2	41,340		
252	0736	0019		23.1	43,020		
253	1217	0123		23.4	43,410		1.5
254	0907	0229		23.5	42,640		

STATION 23 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1155	0845		18.0	36,700	2.5	3.4
174	1252	0930		28.5	24,550	2.8	
174	0841	2130		20.0	33,770	2.0	3.3
175	1154	1030		18.0	40,400	2.3	
175	0750	2215		18.0	35,451	2.0	4.2
176	1235	1130		17.0	35,940	1.7	
176	0723	2315		18.0	31,790	1.9	3.9
177	0935	2346		18.4	27,120	2.5	4.3
177	1327	1221		18.7	35,360	1.6	
180	0746	0227		17.2	26,070	1.5	4.2
180	1131	0227		18.9	32,720	2.8	
181	0735	0320		20.6	20,310	2.0	4.2
181	1138	0320		21.2	34,014	3.1	
182	1144	0445		17.9	36,963	2.6	
182	0750	0445		18.3	22,200	3.2	3.6
183	0749	0530		19.1	32,190	2.2	3.8
183	1200	0530		21.1	31,220	3.5	
184	0750	0600		19.0	27,580	3.2	2.0
184	1143	0600		20.9	23,281	3.2	
187	0737	2000		19.9	36,020	7.0	4.2
187	1152	0800		20.2	29,800	7.2	
188	1147	0820		21.3	26,680	7.0	
188	0747	2030		20.5	31,630	6.0	5.1
189	1132	0915		21.8	34,000	5.2	
189	0737	2150		20.0	36,340	4.3	3.1
190	0742	2120		20.1	35,520	3.8	2.7
190	1130	0955		20.8	40,373	3.7	
191	0730	2330		21.5	35,971	4.4	4.6
191	1108	1040		22.2	22,651	9.2	
194	0805	0120		20.6	36,120	6.1	4.4
194	1136	0120		22.1	25,973	7.6	
195	0740	0130		22.0	12,816	4.4	4.7
195	1211	0130		21.4	31,370	3.5	
196	1307	0230		19.8	25,540	3.0	
196	0914	0230		19.8	17,252	3.1	5.3
197	0739	0330		18.5	19,100	3.6	4.4
197	1233	0330		19.9	23,170	2.6	
198	0842	0440		20.0	19,230	4.0	3.6
198	1242	0440		22.0	24,950	4.1	
201	0744	0725		22.1	27,486	3.4	2.7
201	1202	0725		22.3	18,750	2.7	

STATION 23 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	0856	2115		23.5	24,950	2.9	2.8
203	1219	0930		23.9	13,095	5.2	
204	1343	1015		24.4	11,583	5.5	
204	0938	2215		24.6	19,900	4.4	2.4
205	0856	2315		23.5	14,855	5.0	3.0
205	1308	1115		24.9	14,520	4.4	
206	0810	2400		23.6	18,360	4.0	2.5
206	1223	1215		24.2	17,790	5.5	
209	0747	0230		23.9	12,786	4.0	3.3
209	1223	0230		25.7	20,313	5.4	
210	0808	0315		24.4	12,090	2.1	4.4
210	1237	0315		25.7	22,630	7.5	
211	0754	0415		23.7	13,583	2.9	7.0
211	1240	0415		25.9	20,910	8.3	
214	1227	0600		22.4	18,195	3.5	
214	0756	0600		20.0	24,383	2.7	4.6
215	0756	0710		19.5	39,510	2.0	4.4
215	1208	0710		22.1	29,333	3.9	
216	0756	0730		20.6	39,032	3.3	4.4
216	1248	0730		23.3	31,430	3.1	
217	0852	0830		19.5		4.3	4.7
217	1320	0830		19.5	31,430	3.1	
218	1110	0930		21.9	34,695	2.5	3.1
218	1413	0930		22.2	31,634	2.5	
219	1436	0945		21.9	33,040	2.4	
219	1115	0945		21.0	38,566	2.6	1.0
222	0907			21.1	36,810	1.4	1.0
222	1250	1210		20.9	40,333	1.4	
223	1222	0045		23.6	35,825	2.8	
223	0818	0045		21.7	36,255	1.4	4.2
224	1207	0130		25.1	35,720	3.4	
224	0742	0130		21.9	31,842	1.2	2.4
225	0755	0245		22.6	29,602	1.2	
225	1239	0245		25.2	35,590	3.0	
237	0809	0050		22.1	37,090	1.0	
238	0721	0130		22.9	35,850	1.1	
239	0824	0200		24.5	29,600	3.2	5.4
240	0711	0310		24.2	24,690	2.8	
243	0732	0550		23.6	29,510	1.6	
244	0734	0630		24.4	26,230	2.4	
245	0748	0705		24.2	33,260	2.1	

STATION 23 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
246	0710	1930		25.2	28,140	2.5	3.1
247	0726	2015		25.1	28,640	2.3	
251	0802	2319		24.2	33,040	2.0	
252	0713	0019		25.1	33,850	2.1	
253	1231	0123		25.4	37,810	2.3	2.6
254	0919	0229		22.9	38,260	.7	

STATION 23 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1155	0845		18.0	36,600	2.5	7.2
174	0845	2130		16.0	42,480	2.0	8.7
174	1254	0930		20.5	31,950	2.2	
175	0755	2215		16.0	42,640	2.5	2.8
175	1156	1030		17.5	40,400	2.8	
176	1237	1130		16.3	37,820	1.6	
176	0704	2315		17.0	37,000	1.8	2.7
177	1330	1221		16.8	38,920	1.8	
177	0935	2346		17.2	39,540	2.8	1.4
180	0748	0227		16.3		1.6	3.4
180	1133	0227		16.1	39,000	1.5	
181	0737	0320		18.0	36,015	1.0	3.2
181	1140	0320		17.6	42,735	2.9	
182	1146	0445		16.0	42,553	2.3	
182	0753	0445		15.9	39,000	1.9	1.9
183	0752	0530		18.0	34,380	1.9	2.8
183	1202	0530		17.7		1.1	
184	0752	0600		17.3	41,390	1.4	1.8
184	1145	0600		17.5	42,500	1.3	
187	0739	2000		18.8	39,360	4.4	2.8
187	1154	0800		19.9	32,191	5.8	
188	1148	0820		19.9	26,410	5.4	
188	0750	2030		18.1	41,800	3.0	2.1
189	0742	2150		17.7	41,735	3.0	2.0
189	1134	0915		19.6	40,281	2.8	
190	1132	0955		19.7	41,320	3.0	
190	0745	2120		18.1	42,920	18.1	2.0
191	0732	2330		20.1	39,631	2.2	2.7
191	1110	1040		20.0	39,755	2.3	
194	0807	0120		19.7	40,672	1.8	3.0
194	1138	0120		19.6	41,450	1.3	
195	0743	0130		19.5	39,040	.8	4.3
195	1213	0130		20.2	37,461	1.9	
196	0915	0230		19.0	37,140	1.3	2.5
197	0741	0330		18.5	30,630	1.9	4.2
197	1234	0330		18.6	40,575	1.0	
198	0844	0440		19.8	21,622	3.1	5.2
198	1243	0440		19.4	42,304	1.3	
201	0746	0725		19.9	40,541	1.7	1.4
201	1203	0725		22.3	22,090	2.6	
203	0857	2115		20.3	40,541	1.3	2.7

STATION 23 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	1220	0930		22.8	15,570	4.2	
204	1344	1015		23.6	15,980	4.3	
204	0939	2215		20.8	38,920	1.1	1.4
205	0858	2315		20.1	39,553	1.2	2.6
205	1311	1115		22.1	36,040	1.2	
206	0812	2400		20.0	40,290	1.0	1.4
206	1224	1215		20.4	39,080	1.3	
209	1224	0230		20.0	42,490	1.3	
209	0748	0230		20.0	41,404	1.9	1.9
210	0809	0315		20.3	41,760	1.2	.6
210	1238	0315		21.1	38,920	.8	
211	1241	0415		21.2	41,640	.4	
211	0755	0415		20.6	39,280	.7	3.4
214	0758	0600		18.2	43,410	.3	1.3
214	1229	0600		19.2	42,456	.2	
215	0758	0710		18.0	44,000	.7	1.2
215	1210	0710		19.3	43,604	.4	
216	0757	0730		18.3	43,801	.9	1.0
216	1250	0730		21.5	34,695	1.8	
217	0854	0830		18.4		1.1	3.3
217	1321	0830		20.0	32,270	2.2	
218	1112	0930		21.7	36,120	2.1	2.5
218	1415	0930		22.0	37,090	2.0	
219	1116	0945		20.3	40,844	1.4	1.6
219	1437	0945		21.7	33,265	2.1	
222	0910			20.8	39,350	1.0	1.5
222	1251	1210		20.1	40,672	.8	
223	1224	0045		21.0	41,724	.9	
223	0819	0045		20.6	41,191	1.1	.8
224	0744	0130		20.9	41,191	.7	1.5
224	1209	0130		21.4	42,460	1.0	
225	0756	0245		21.0	40,502	1.0	
225	1240	0245		21.9	42,090	1.0	
237	0812	0050		22.0	40,500	2.0	
238	0723	0130		22.5	43,600	1.2	
239	0835	0200		23.3	41,190	1.2	2.3
240	0712	0310		23.8	37,520	2.1	
243	0733	0550		22.0	42,270	.5	
244	0735	0630		22.3	41,400	.7	
245	0749	0705		22.9	42,000	1.0	
246	0713	1930		23.2	40,670	1.5	1.8

STATION 23 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
247	0729	2015		22.5	42,640	.3	
251	0804	2319		23.2	41,160	.2	
252	0715	0019		24.3	40,000	1.7	
253	1233	0123		23.8	39,350	.6	2.2
254	0920	0229		22.3	44,000	.3	

STATION 24 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1215	0845		18.0	31,700	2.3	
174	0852	2130		19.0	37,670	2.1	
174	1254	0930		22.5	21,810	3.4	
175	1208	1030		19.5	38,020	2.3	
175	0810	2215		18.5	36,640	2.1	
176	1248	1130		17.9	31,730	1.6	
176	0714	2315		17.5	27,820	1.8	
177	0955	2346		18.2	32,620	1.2	
177	1317	1221		19.1	32,890	1.4	
160	0800	0227		17.1	19,500	2.1	
180	1142	0227		18.2	31,700	1.7	
181	0753	0320		22.1	16,500	1.3	
181	1200	0320		20.9	30,211	1.7	
182	1205	0445		19.2	33,270	2.9	
182	0803	0445		18.6	20,565	3.3	
183	0759	0530		20.0	25,196	2.4	
183	1221	0530		20.4	31,510	2.6	
184	1155	0600		20.5	23,590	4.3	
184	0811	0600		19.5	22,990	3.3	
187	0753	2000		19.8	36,340	6.4	
187	1206	0800		20.0	29,380	6.1	
188	1206	0820		21.9	20,940	6.5	
188	0806	2030		19.8	36,080	5.7	
189	0759	2150		18.9	40,080	3.3	
189	1145	0915		21.8	29,330	5.0	
190	0803	2120		19.0	38,140	19.0	
190	1147	0955		20.6	39,153	3.2	
191	0743	2330		21.2	34,464	4.1	
191	1117	1040		22.0	13,760	5.5	
194	0814	0120		21.9	38,261	4.7	
194	1152	0120		22.9	29,515	5.7	
195	0811	0130		21.7	10,170	4.8	
195	1231	0130		20.8	30,343	4.3	
196	1315	0230		20.0	25,673	3.1	
196	0921	0230		18.9	14,310	3.5	
197	0758	0330		18.2	15,761	4.1	
197	1241	0330		20.0	18,711	3.6	
198	0903	0440		21.7	16,790	4.3	
198	1253	0440		20.8	24,264	3.2	
201	1213	0725		23.4	19,900	3.1	
201	0803	0725		21.7	24,885	2.2	

STATION 24 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	0912	2115		23.4	25,540	3.0	
203	1232	0930		23.8	9,270	5.3	
204	0950	2215		23.8	24,760	3.0	
204	1330	1015		25.3	5,915	6.4	
205	0914	2315		23.0	20,530	3.8	
205	1253	1115		24.3	12,460	4.3	
206	0828	2400		23.8	11,723	3.9	
206	1242	1215		24.1	13,666	4.5	
209	0806	0230		24.1	11,866	4.1	
209	1243	0230		25.2	21,526	3.8	
210	0824	0315		25.0	9,810	2.2	
210	1245	0315		26.0	19,382	3.9	
211	0808	0415		23.9	8,504	3.3	
211	1248	0415		25.7	21,980	8.5	
214	1235	0600		22.4	18,722	4.0	
214	0815	0600		20.7	19,440	3.1	
215	0813	0710		19.4	30,440	3.6	
215	1218	0710		22.8	27,345	3.9	
216	0817	0730		20.3	38,720	3.3	
216	1255	0730		23.9	31,950	3.4	
217	0903	0830		19.9	37,302	4.2	
217	1328	0830		19.3	27,115	3.5	
218	1133	0930		21.6	30,156	3.2	
218	1422	0930		22.7	31,226	3.0	
219	1133	0945		21.3	33,040	2.8	
219	1506	0945		23.7	30,300	2.5	
222	0917			21.1	32,270	1.8	
222	1258	1210		21.0	34,450	2.1	
223	1234	0045		23.0	37,374	2.4	
223	0836	0045		21.9	34,820	1.5	
224	0750	0130		22.3	25,575	1.7	
224	1219	0130		23.0	40,166	1.8	
225	0814	0245		23.1	27,580	1.1	
225	1245	0245		23.3	38,565	2.4	

STATION 24 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1215	0845		19.0	32,400	2.4	
174	0854	2130		16.5	40,040	2.2	
174	1305	0930		19.5	33,820	2.0	
175	0812	2215		17.0	40,430	2.6	
175	1210	1030		16.9	40,080	2.1	
176	1251	1130		16.8	38,190	1.6	
176	0717	2315		17.5	35,020	1.6	
177	1319	1221		17.2	38,120	1.9	
177	0958	2346		17.3	39,080	1.8	
180	0803	0227		16.9	33,670	.7	
180	1144	0227		16.4	39,600	1.4	
181	0754	0320		19.8	35,470	.9	
181	1202	0320		18.3	39,333	2.1	
182	1206	0445		16.8	41,375	1.9	
182	0905	0445		16.8	37,634	1.7	
183	0800	0530		18.2	36,740	2.0	
183	1222	0530		18.8	36,330	1.3	
184	0812	0600		16.9	41,890	1.3	
184	1157	0600		18.9	32,280	1.6	
187	0755	2000		19.4	36,600	6.1	
187	1207	0800		19.8	30,620	5.9	
188	1208	0820		20.0	33,330	4.5	
188	0808	2030		18.3	38,580	3.6	
189	0801	2150		17.6	41,901	2.5	
189	1147	0915		18.5	41,792	2.2	
190	1148	0955		20.0	38,840	3.2	
190	0805	2120		18.0	41,933	2.0	
191	0745	2330		20.0	38,582	3.2	
191	1119	1040		20.0	36,480	2.4	
194	0816	0120		19.8	40,000	1.8	
194	1159	0120		20.0	39,274	1.7	
195	0813	0130		21.0	25,364	2.4	
195	1233	0130		19.8	40,082	1.4	
196	0922	0230		19.9	28,285	1.3	
196	1317	0230		18.7	40,210	1.3	
197	0759	0330		18.4	29,075	1.2	
197	1243	0330		18.6	37,351	1.3	
198	0905	0440		20.1	20,813	3.3	
198	1256	0440		19.9	38,611	1.4	
201	0805	0725		20.0	39,076	1.9	
201	1217	0725		22.8	23,222	2.2	

STATION 24 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	0913	2115		20.2	38,765	1.3	
203	1234	0930		23.4	8,461	5.5	
204	0952	2215		21.3	38,765	1.2	
204	1331	1015		22.7	28,121	2.0	
205	0915	2315		20.4	36,306	1.8	
205	1255	1115		21.2	38,310	1.2	
206	0829	2400		21.0	36,650	1.5	
206	1243	1215		21.5	36,720	1.4	
209	1244	0230		20.3	41,940	1.0	
209	0807	0230		21.6	34,630	1.9	
210	0826	0315		22.1	35,510	.7	
210	1246	0315		21.2	40,210	.7	
211	1250	0415		21.3	40,083	.4	
211	0810	0415		22.7	29,640	1.6	
214	0817	0600		19.8	38,720	.7	
214	1237	0600		20.6	33,611	.6	
215	0814	0710		18.8	42,460	.5	
215	1220	0710		20.3	33,965	1.6	
216	0819	0730		19.3	41,905	1.0	
216	1257	0730		21.6	35,852	1.5	
217	0904	0830		19.7	40,333	2.3	
217	1329	0830		20.1	33,380	1.8	
218	1134	0930		21.0	40,166	1.4	
218	1423	0930		22.0	27,202	1.7	
219	1134	0945		20.3	40,333	1.3	
219	1508	0945		21.9	34,450	1.5	
222	0918			20.6	40,000	1.1	
222	1259	1210		20.4	40,502	.8	
223	1235	0045		21.5	40,590	1.2	
223	0837	0045		21.3	40,333	1.0	
224	0752	0130		21.8	35,720	.6	
224	1220	0130		21.8	41,724	1.0	
225	0815	0245		22.5	35,720	.4	
225	1246	0245		21.4	41,724	1.1	

STATION 25 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1225	0845		19.0	23,350	2.6	
174	0859	2130		18.0	36,890	2.1	
174	1316	0930		23.5	18,040	4.4	
175	1221	1030		21.2	30,570	2.5	
175	0835	2215		18.5	35,700	1.9	
176	1300	1130		18.5	17,980	3.2	
176	0729	2315		18.0	28,880	1.2	
177	1010	2346		18.5	30,320	1.2	
177	1307	1221		19.9	23,740	1.3	
180	0811	0227		17.8	24,100	.8	
180	1154	0227		19.1	30,200	1.3	
181	0805	0320		21.5	89,231	3.6	
181	1212	0320		20.5	29,412	1.6	
182	1217	0445		18.2	31,923	1.5	
182	0919	0445		19.3	15,770	3.1	
183	0807	0530		20.8	16,294	3.5	
183	1232	0530		19.9	30,610	1.2	
184	0823	0600		19.4	17,950	3.7	
187	0802	0800		20.0	35,600	6.2	
187	1220	0800		21.0	20,613	7.2	
188	1223	0820		23.0	14,670	7.5	
188	0819	2030		20.1	35,210	5.0	
189	0821	2150		19.8	40,240	3.1	
189	1205	0915		23.0	23,490	6.0	
190	0816	2120		19.8	38,385	2.9	
190	1202	0955		21.8	36,641	4.9	
191	0751	2330		21.7	33,433	4.0	
191	1139	1040		22.1	14,100	5.8	
194	0824	0120		21.5	37,370	4.2	
194	1208	0120		22.4	29,340	5.1	
195	0825	0130		21.9	10,940	4.0	
195	1242	0130		21.1	27,830	4.0	
196	0927	0230		19.8	9,180	4.3	
196	1325	0230		18.2	25,741	2.6	
197	0812	0330		13.9	12,990	4.5	
197	1257	0330		19.8	18,020	3.5	
198	0921	0440		22.0	10,790	5.0	
198	1318	0440		22.8	18,856	4.2	
201	0822	0725		22.3	19,153	3.2	
201	1237	0725		24.2	12,162	4.6	
203	0922	2115		23.7	11,044	4.4	

STATION 25 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	1249	0930		24.6	3,892	6.5	
204	1005	2215		24.4	10,850	4.4	
204	1319	1015		26.2	3,532	7.6	
205	0930	2315		22.6	19,004	3.9	
205	1231	1115		25.3	6,490	5.1	
206	0838	2400		23.7	10,041	4.2	
206	1255	1215		24.9	6,277	4.2	
209	0825	0230		24.2	12,803	3.7	
209	1258	0230		26.9	10,692	4.4	
210	0835	0315		25.1	8,041	2.4	
210	1300	0315		26.3	14,810	3.5	
211	0824	0415		24.8	4,445	2.7	
211	1302	0415		25.2	15,261	4.1	
214	1243	0600		22.4	18,264	3.5	
214	0832	0600		20.3	12,100	3.5	
215	0827	0710		20.0	24,212	4.7	
215	1240	0710		23.5	24,200	5.8	
216	0836	0730		20.9	32,270	3.2	
216	0836	0730		20.9	32,270	3.2	
216	1303	0730		24.0	29,245	4.4	
217	0913	0830		19.6		4.7	
217	1336	0830		19.7	22,512	4.2	
218	1143	0930		22.1	26,814	3.8	
218	1432	0930		22.3	30,170	3.5	
219	1142	0945		21.7	30,156	3.6	
219	1517	0945		23.0	29,422	2.2	
222	0929			21.0	33,380	1.2	
222	1310	1210		21.7	26,092	3.9	
223	1242	0045		22.9	38,720	2.4	
223	0844	0045		21.9	33,495	1.8	
224	0820	0130		22.5	30,156	.7	
224	1234	0130		23.3	38,413	1.6	
225	0826	0245		23.4	27,740	.8	
225	1252	0245		23.8	35,590	2.2	

STATION 25 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1225	0845		18.0	32,800	1.7	
174	0902	2130		17.0	37,030	1.8	
174	1319	0930		19.5	33,410	1.8	
175	1223	1030		17.5	38,113	2.2	
175	0838	2215		16.5	37,660	4.2	
176	1303	1130		16.8	35,810	1.8	
176	0730	2315		17.8	33,680	1.0	
177	1308	1221		17.6	36,740	1.4	
177	1011	2346		17.1	36,590	1.4	
180	0813	0227		16.9	36,290	.2	
180	1156	0227		17.4	37,625	1.0	
181	0807	0320		18.7	35,564		
181	1214	0320		18.0	38,580	1.5	
182	0920	0445		16.3	38,250	1.3	
182	1219	0445		17.0	39,370	1.3	
183	0809	0530		18.1	37,132	1.0	
183	1233	0530		18.3	36,710	.4	
184	0824	0600		17.6	37,230	1.5	
184	1213	0600		18.3	39,016	.9	
187	0804	0800		19.7	36,090	5.8	
187	1222	0800		19.9	33,864	2.8	
188	1225	0820		21.7	22,360	6.9	
188	0821	0820		19.2	37,160	4.3	
189	0822	2150		18.2	41,102	2.7	
189	1206	0915		20.0	35,070	4.4	
190	1204	0955		19.9	39,633	2.9	
190	0816	2120		18.7	39,603	2.6	
191	0753	2330		20.4	36,875	3.4	
191	1141	1040		21.4	31,420	4.0	
194	0826	0120		20.1	37,961	1.4	
194	1210	0120		20.0	38,050	1.8	
195	0826	0130		20.5	30,630	1.3	
195	1244	0130		19.9	37,320	1.6	
196	1326	0230		18.8	39,076	1.2	
196	0928	0230		19.7	33,494	1.2	
197	0813	0330		19.0	26,253	1.2	
197	1258	0330		18.7	37,280	1.1	
198	0923	0440		19.7	29,485	1.5	
198	1320	0440		20.1	35,000	2.2	
201	0823	0725		21.3	32,380	1.7	
201	1239	0725		22.4	27,030	1.4	

STATION 25 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	0923	2115		21.7	34,382	1.5	
203	1250	0930		24.1	3,012	6.5	
204	1007	2215		21.7	36,442	1.4	
204	1320	1015		23.8	11,250	4.1	
205	0932	2315		20.5	35,382	1.7	
205	1233	1115		21.4	37,452	1.5	
206	0839	2400		20.7	33,322	1.4	
206	1257	1215		21.0	36,720	1.1	
209	0826	0230		21.8	35,254	1.1	
209	1300	0230		21.7	40,882	.9	
210	0837	0315		20.9	35,772	.4	
210	1301	0315		21.4	37,423	.7	
211	1304	0415		21.2	16,290	.5	
211	0826	0415		21.8	32,611	.2	
214	0834	0600		19.9	37,812	.4	
214	1245	0600		20.9	36,255	.3	
215	0829	0710		18.7	40,333	.6	
215	1243	0710		20.1	38,720	.3	
216	0837	0730		20.0	38,720	2.2	
216	1304	0730		20.4	38,720	.4	
217	0914	0830		19.9		3.2	
217	1337	0830		19.8	34,695	1.2	
218	1144	0930		21.7	26,964	2.1	
218	1434	0930		21.2	32,160	.9	
219	1143	0945		20.6	39,510	1.4	
219	1518	0945		20.9	37,961	.9	
222	0630			20.9	37,520	.8	
222	1311	1210		20.9	38,413	.9	
223	1244	0045		21.6	37,213	1.8	
223	0845	0045		21.3	37,231	.6	
224	0821	0130		21.9	35,720	.4	
224	1236	0130		22.5	39,672	1.4	
225	0828	0245		22.2	37,090	.2	
225	1253	0245		22.1	40,000	1.0	

STATION 26 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1235	0845		18.0	32,800	1.6	3.8
174	0910	2130		18.5	33,730	2.4	2.2
174	1340	0930		20.5	30,180	2.1	
175	1234	1030		20.5	29,736	2.1	
175	0850	2215		19.0	31,230	1.5	
176	1311	1130		18.0	31,360	1.5	
176	0745	2315		18.0	24,590	1.3	3.6
177	1019	2346		18.8	28,010	.5	6.7
177	1251	1221		18.1	32,300	1.4	
180	0821	0227		17.8	19,620	1.5	3.4
180	1204	0227		20.0	21,350	2.1	
181	0818	0320		22.3	67,470	4.9	6.7
181	1226	0320		23.8	12,031	5.5	
182	0929	0445		18.8	16,780	3.2	4.8
182	1227	0445		18.8	28,330	1.3	
183	0814	0530		20.1	18,643	2.0	5.1
183	1243	0530		22.0	20,340	3.4	
184	0836	0600		20.1	24,560	2.6	2.9
184	1226	0600		21.2	24,590	2.2	
187	0812	0800		20.5	29,100	5.3	6.0
187	1233	0800		21.0	17,555	5.8	
188	1238	0820		21.5	30,500	4.9	
188	0836	0820		20.6	33,340	4.2	5.0
189	1218	0915		22.2	29,590	4.1	
189	0833	2150		20.5	33,100	4.2	4.7
190	0827	2120		20.8	34,483	3.2	
190	1217	0955		22.8	30,344	5.4	
191	0759	2330		21.2	31,541	3.6	4.2
191	1149	1040		22.3	9,276	5.4	
194	0833	0120		21.7	34,210	4.4	3.3
194	1226	0120		23.6	13,875	4.7	
195	0850	0130		22.0	8,470	3.9	3.3
195	1251	0130		22.1	9,634	4.8	
196	0934	0230		20.0	10,933	3.6	5.2
196	1336	0230		20.5	10,300	4.8	
197	0822	0330		19.0	13,380	3.9	14.5
197	1310	0330		20.0	15,470	3.5	
198	0944	0440		22.0	11,590	5.8	10.8
198	1334	0440		23.0	14,061	5.0	
201	0834	0725		22.1	16,922	2.7	5.1
201	1251	0725		23.3	18,018	3.2	

STATION 26 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	0932	0930		23.3	2,940	6.1	4.0
203	1304	0930		24.8	3,031	6.1	
204	1304	1015		25.7	3,354	7.2	
204	1022	1015		25.3	2,115	6.7	4.6
205	0944	2315		23.6	9,356	4.6	4.4
205	1217	1115		24.9	6,120	5.2	
206	0849	2400		24.1	6,960	3.6	4.5
206	1313	1215		24.5	8,110	3.8	
209	0833	0230		24.3	9,270	4.0	5.2
209	1309	0230		28.0	7,051	5.2	
210	0845	0315		25.4	6,160	2.4	5.5
210	1310	0315		28.3	6,081	4.4	
211	0838	0415		24.8	2,514	.7	8.7
211	1317	0415		27.1	4,255	4.6	
214	1251	0600		22.3	20,596	2.9	
214	0847	0600		20.5	12,890	2.7	11.0
215	0842	0710		19.8	31,790	2.0	11.4
215	1252	0710		23.7	28,470	3.5	
216	0849	0730		21.5	26,814	2.8	12.5
216	1311	0730		24.8	27,310	1.0	
217	0924	0830		20.1		2.6	5.4
217	1345	0830		20.0	28,895	2.8	
218	1154	0930		21.8	29,070	2.2	9.3
218	1516	0930		22.8	30,250	3.8	
219	1151	0945		22.0	28,470	2.6	8.4
219	1529	0945		22.0	34,820	1.6	
222	1322	1210		21.7	26,670	2.3	
222	0939			21.3	30,730	1.2	
223	1251	0045		24.2	31,950	2.7	
223	0857	0045		22.4	31,026	1.1	8.2
224	0830	0130		23.1	20,820	2.6	5.3
224	1243	0130		23.8	34,571	1.3	
225	0838	0245		23.8	25,340	1.4	
225	1300	0245		24.3	33,380	1.6	

STATION 26 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1235	0845		18.0	37,500	.6	6.9
174	0912	2130		19.0	36,210	2.2	2.7
174	1342	0930		19.0	35,220	1.5	
175	1236	1030		17.5	37,400	2.1	
175	0853	2215		17.5	33,300	1.8	2.2
176	1312	1130		17.5	34,010	1.3	
176	0747	2315		17.5	31,720	.8	5.2
177	1253	1221		18.1	35,090	1.4	
177	1021	2346		18.1	30,270	.6	2.7
180	0823	0227		17.3	31,080	.5	3.4
180	1206	0227		17.6	35,840	.1	
181	0821	0320		18.2	32,300		3.2
181	1231	0320		19.0	34,423	.6	
182	0931	0445		16.7	38,530	.9	1.5
182	1229	0445		18.0	25,320	.2	
183	0816	0530		18.0	36,727	.2	2.0
183	1244	0530		19.0	36,350	.1	
184	0838	0600		16.9	37,780	1.3	1.6
184	1228	0600		18.4	36,434	.7	
187	0814	0800		20.0	35,580	5.3	5.0
187	1234	0800		19.8	33,974	1.4	
188	1239	0820		19.8	34,720	.6	
188	0836	0820		19.9	35,960	3.7	3.5
189	0835	2150		18.9	38,360	2.7	1.4
189	1220	0915		19.1	39,683	3.1	
190	1219	0955		19.8	38,380	2.8	
190	0829	2120		19.8	37,052	2.0	1.4
191	0801	2330		20.4	35,820	1.5	3.4
191	1151	1040		20.5	20,901	4.0	
194	0835	0120		21.3	36,120	2.2	4.4
194	1228	0120		20.4	33,590	2.0	
195	0851	0130		22.0	12,715	3.1	4.6
195	1252	0130		20.2	35,941	1.2	
196	0935	0230		19.6	19,116	2.5	3.0
196	1338	0230		19.0	36,306	1.2	
197	0824	0330		18.8	20,334	3.2	3.3
197	1312	0330		19.6	24,144	2.0	
198	0946	0440		19.6	33,670	.7	10.1
198	1336	0440		20.8	21,816	2.9	
201	0836	0725		21.2	29,850	1.9	3.0
201	1253	0725		22.8	16,790	2.9	

STATION 26 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	0934	0930		21.8	27,642	1.9	2.3
203	1305	0930		22.7	6,120	5.1	
204	1024	1015		22.6	27,030	2.4	2.2
204	1305	1015		23.4	10,041	3.6	
205	0946	2315		22.4	22,630	2.5	3.5
205	1219	1115		22.2	35,904	1.8	
206	0850	2400		22.4	23,732	1.9	2.3
206	1314	2155		21.4	32,220	1.6	
209	0835	0230		21.6	30,390	.8	3.6
209	1311	0230		21.1	38,160	.7	
210	0846	0315		21.8	34,382	.2	2.4
210	1311	0315		23.0	34,750	.4	
211	1319	0415		22.3	33,310	.6	
211	0840	0415		21.7	34,080		3.9
214	0849	0600		19.8	37,520	.4	3.8
214	1253	0600		20.6	34,820	.2	
215	1254	0710		22.1	30,250	2.1	
215	0844	0710		19.8	39,190	.7	4.6
216	0851	0730		20.0	39,350	1.7	4.4
216	1313	0730		21.6	38,566	.4	
217	0925	0830		19.9	38,643	3.1	4.3
217	1346	0830		20.2	31,380	1.8	
218	1155	0930		21.1	38,566	1.1	4.3
218	1517	0930		21.5	31,740	.5	
219	1152	0945		20.5	38,875	1.3	3.0
219	1530	0945		21.6	36,670	.8	
222	0941			21.0	35,852	.4	3.0
222	1323	1210		20.9	37,520	1.0	
223	0854	0045		21.6	36,120	.3	4.2
223	1252	0045		22.0	38,690	1.1	
224	0832	0130		21.8	35,851	.2	2.3
224	1245	0130		22.3	39,720	.7	
225	1301	0245		22.6	37,812	.1	
225	0839	0245		22.5	35,330		

STATION 27 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1245	0845		19.5	28,000	2.0	
174	0922	2130		19.0	30,970	1.9	
174	1350	0930		20.5	28,660	1.0	
175	1243	1030		19.5	21,360	2.6	
175	0907	2215		18.5	29,430	1.1	
176	1320	1130		18.2	28,750	1.1	
176	0753	2315		18.5	19,450	1.8	
177	1029	2346		19.2	25,450	.5	
177	1234	1221		19.1	28,130	.4	
180	0836	0227		17.8	23,110	.6	
180	1215	0227		19.2	24,735	1.5	
181	0833	0520		22.3	12,070	2.8	
181	1239	0320		20.9	21,610	1.4	
182	0838	0445		19.1	20,180	1.0	
182	1237	0445		19.9	25,320	.6	
183	0825	0530		20.0	28,822	1.2	
183	1252	0530		22.1	14,470	4.6	
184	0849	0600		19.7	24,120	1.8	
184	1236	0600		22.5	24,470	3.1	
187	0822	0800		20.7	25,080	5.4	
187	1244	0800		22.0	9,070	8.0	
188	1252	0820		21.3	30,140	4.0	
188	0852	0820		21.2	26,710	4.2	
189	0844	2150		21.1	30,610	3.8	
189	1229	0915		21.8	31,060	2.7	
190	0840	2120		21.5	31,990	3.2	
190	1231	0955		21.9	30,985	4.3	
191	1201	1040		23.0	9,365	7.6	
191	0813	2330		22.4	28,370	5.1	
194	0843	0120		22.0	29,245	5.6	
194	1241	0120		24.2	8,254	7.1	
195	0901	0130		22.0	6,960	3.9	
195	1257	0130		21.3	18,310	3.6	
196	0942	0230		19.0	9,730	5.4	
196	1344	0230		20.3		5.2	
197	0840	0330		19.0	15,510	4.3	
197	1321	0330		20.2	12,162	4.5	
198	0957	0440		21.4	8,766	6.1	
198	1346	0440		22.8	10,542	5.5	
201	0847	0725		22.0	23,732	2.0	
201	1259	0725		23.5	12,770	4.9	

STATION 27 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	0942	0930		23.9	1,125	7.8	
203	1320	0930		24.4	2,783	6.6	
204	1031	1015		25.1	1,080	8.1	
204	1255	1015		25.3	2,630	6.8	
205	0955	2315		23.8	4,793	6.1	
205	1206	1115		24.1	4,176	5.6	
206	0858	2400		24.3	6,100	3.9	
206	1328	1215		24.9	5,560	6.4	
209	0841	0230		24.3	8,845	4.1	
209	1316	0230		25.8	7,485	4.5	
210	0853	0315		24.7	5,260	4.3	
210	1317	0315		27.1	5,070	5.1	
211	0848	0415		24.6	2,385	4.0	
211	1330	0415		26.6	4,371	3.5	
214	1259	0600		23.1	22,304	3.6	
214	0903	0600		20.7	19,675	2.8	
215	0850	0710		20.4	25,474	2.4	
215	1302	0710		23.9	28,221	1.9	
216	0859	0730		21.7	26,814	1.7	
216	1317	0730		26.0	28,470	3.9	
217	0932	0830		20.0	26,270	1.4	
217	1355	0830		20.3	28,470	2.5	
218	1203	0930		22.2	27,636	2.1	
218	1522	0930		22.2	30,270	1.7	
219	1538	0945		23.0	29,333	1.4	
219	1159	0945		21.3	33,380	1.2	
222	0948			21.7	36,233	2.2	
222	1329	1210		22.0	23,901	3.8	
223	0901	0045		22.7	26,200	2.2	
223	1259	0045		25.1	22,000	3.4	
224	0842	0130		23.2	26,021	1.5	
224	2500	1300		27.2	19,755	.4	
225	0845	0245		24.0	19,795	2.1	
225	1307	0245		25.1	29,333	2.3	

STATION 27 BOTTOM

	TIME OF						
YEAR (DAYS) (1)	DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1245	0845		18.0	35,800	.7	
174	1352	0930		18.5	34,800	1.1	
174	0924	2130		18.0	35,650	1.8	
175	0910	2215		17.5	35,760	.7	
175	1246	1030		17.5	37,740	2.0	
176	1322	1130		17.8	34,500	1.3	
176	0755	2315		18.5	32,640	.1	
177	1236	1221		17.8	35,100	.8	
177	1031	2346		17.9	34,147	.2	
180	0837	0227		17.2	36,020	.1	
180	1217	0227		17.5	36,240		
181	0835	0320		17.8	34,752		
181	1242	0320		18.8	34,590	.5	
182	0840	0445		17.0	37,000		
182	1239	0445		18.3	35,590		
183	0826	0530		18.2	37,684	.4	
183	1254	0530		19.2	37,270		
184	0851	0600		17.8	36,010	1.2	
184	1237	0600		18.8	37,245		
187	0824	0800		19.8	35,720	2.2	
187	1245	0800		18.4	34,422		
188	1253	0820		19.8	33,770	1.7	
188	0854	0820		20.0	33,849	3.5	
189	0845	2150		19.8	38,360	2.4	
189	1230	0915		18.9	38,461	2.7	
190	1231	0955		19.8	38,510	1.9	
190	0842	2120		19.8	37,585	1.5	
191	0815	2330		20.8	28,450	1.5	
191	1203	1040		20.4	31,220	1.1	
194	0845	0120		20.7	36,806	.2	
194	1243	0120		21.0	34,540	1.9	
195	0903	0130		20.8	26,910	1.6	
195	1259	0130		20.0	32,252	1.4	
196	1345	0230		19.7	34,874	1.0	
196	0943	0230		20.1	24,325	.1	
197	0842	0330		19.4	20,635	3.5	
197	1322	0330		19.8	25,540	2.1	
198	0959	0440		19.9	26,505	2.0	
198	1348	0440		20.3	20,680	2.8	
201	0849	0725		20.7	30,600	1.0	
201	1300	0725		21.6	27,880	.5	

STATION 27 BOTTOM

	TIME OF						
YEAR (DAYS) (1)	DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	0943	0930		21.8	27,960	1.9	
203	1321	0930		23.2	9,830	4.9	
204	1032	1015		22.2	27,180	2.4	
204	1256	1015		22.6	20,190	2.9	
205	0956	2315		22.1	24,510	2.3	
205	1208	1115		21.9	35,641	1.6	
206	0859	2400		22.4	22,164	1.9	
206	1330	1215		21.9	31,390	1.4	
209	1317	0230		21.4	37,140	.7	
209	0842	0230		21.3	34,750	.8	
210	1319	0315		22.0	35,000	.3	
210	0855	0315		22.4	32,872	.2	
211	1331	0415		22.4	30,190	.2	
211	0850	0415		22.5	24,450	.8	
214	0904	0600		20.2	33,965	.6	
214	1300	0600		21.0	36,255		
215	0852	0710		19.5	40,333	.4	
215	1303	0710		21.2	35,330	.2	
216	0900	0730		20.6	40,420	.3	
216	1318	0730		22.0	38,566		
217	0933	0830		19.7		1.5	
217	1356	0830		19.9	37,090	1.0	
218	1204	0930		21.2	37,231	1.0	
218	1523	0930		21.4	36,670	.2	
219	1200	0945		20.4	40,333	1.2	
219	1540	0945		21.1	37,374	.5	
222	0949			21.0	36,255		
222	1330	1210		21.0	37,374	.9	
223	0902	0045		21.8	35,985	.1	
223	1300	0045		22.1	36,670	.7	
224	0844	0130		22.0	35,590		
224	1251	0130		22.8	35,852	.2	
225	0847	0245		22.2	35,200		
225	1308	0245		22.8	37,235		

STATION 28 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1255	0845		20.0	23,600	3.1	4.3
174	1400	0930		21.0	29,570	.9	
174	0932	0930		19.0	14,880	4.2	2.0
175	1258	1030		19.0	34,100	1.0	
175	0915	2215		19.5	23,300	2.3	8.8
176	1331	1130		18.7	16,852	2.2	
176	0812	2315		19.0	14,170	2.9	4.2
177	1040	2346		19.1	21,720	1.8	4.2
177	1258	1221		19.3	13,960	3.2	
180	0844	0227		17.8	43,470	4.2	3.8
180	1226	0227		21.1	66,580	6.3	
181	0847	0320		21.0	15,131	4.8	4.1
181	1255	0320		22.6	18,260	1.7	
182	0848	0445		18.6	26,911	1.2	.9
182	1248	0445		20.3	20,750	2.1	
183	0831	0530		20.1	12,084	3.6	5.8
183	1302	0530		23.2	88,360	6.2	
184	0903	0600		20.0	25,240	2.5	3.2
184	1245	0600		21.3	27,780	1.2	
187	0831	0800		20.3	29,400	3.8	
187	1252	0800		22.0	6,729	8.0	
188	1304	0820		22.0	22,530	5.0	
188	0906	0820		21.7	15,310	5.9	5.1
189	1241	0915		21.7	30,994	3.2	
189	0858	2150		20.3	23,543	4.1	4.8
190	0852	2120		21.9	24,502	5.0	4.1
190	1251	0955		22.2	32,120	3.9	
191	0818	2330		20.8	34,844	6.2	5.2
191	1209	1040		23.9	6,370	8.9	
194	0901	0120		22.1	21,275	6.1	3.7
194	1255	0120		24.2	4,246	8.2	
195	0910	0130		21.7	6,090	5.6	3.8
195	1305	0130		22.0	5,800	6.7	
196	0949	0230		20.0	11,321	5.6	3.8
196	1352	0230		20.0	8,690	6.3	
197	0853	0330		19.0	11,195	6.2	4.1
197	1332	0330		20.0	11,583	5.6	
198	1006	0440		21.7	7,850	7.6	9.7
198	1357	0440		22.2	3,876	7.8	
201	0859	0725		22.8	14,700	3.9	3.8
201	1307	0725		23.8	11,723	4.8	

STATION 28 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	0951	0930		23.7	2,630	7.9	4.1
203	1329	0930		24.1	3,475	7.8	
204	1043	1015		25.2	3,140	7.6	3.7
204	1245	1015		26.0	3,344		
205	1004	2315		23.9	2,252	7.6	4.0
205	1155	1115		24.4	5,861	6.2	
206	0911	2400		23.9	5,723	5.5	2.4
206	1340	1215		24.3	8,845	5.9	
209	0848	0230		23.9	8,845	4.9	4.0
209	1325	0230		27.3	4,160	7.5	
210	1328	0315		26.3	3,463	8.4	
210	0902	0315		24.8	3,371	6.4	12.8
211	0900	0415		25.3	3,012	5.7	11.4
211	1339	0415		25.7	3,190	8.3	
214	1307	0600		23.0	24,322	4.5	
214	0915	0600		21.3	26,964	2.4	4.0
215	0908	0710		21.2	32,270	1.0	5.6
215	1310	0710		22.6	32,280	2.4	
216	0908	0730		22.2	29,333	.5	4.3
216	1323	0730		24.7	27,660	4.4	
217	0939	0830		20.3	19,283	4.0	5.6
217	1403	0830		20.2	38,566	3.1	
218	1214	0930		22.1	29,333	3.0	5.4
218	1529	0930		22.8	27,270	4.3	
219	1207	0945		22.0	29,512	2.8	4.5
219	1545	0945		22.7	27,580	4.8	
222	1337	1210		21.9	24,261	2.9	
222	0957			21.7	26,814	2.2	4.7
223	0909	0045		22.8	19,400	3.4	4.0
223	1308	0045		24.5	19,715	3.2	
224	0849	0130		23.0	26,593	1.0	4.6
224	1259	0130		26.2	18,440	4.1	
225	0853	0245		23.6	15,172	.8	
225	1314	0245		26.4	19,755	1.6	
225	1322	0245		24.4	18,264	3.4	

STATION 28 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1255	0845		18.0	36,500	.8	2.8
174	1403	0930		19.0	34,610	.4	
174	0934	0930		17.0	36,020	.2	4.6
175	0918	2215		18.1	34,270	.8	2.2
175	1301	1030		18.1	36,870	.8	
176	1334	1130		17.6	33,040	.2	
176	0813	2315		17.5	34,480	.3	2.5
177	1259	1221		18.1	33,800	.2	
177	1043	2346		18.0	33,710	.2	3.7
180	0846	0227		17.0	35,440	.6	2.2
180	1229	0227		18.0	35,071		
181	0849	0320		18.4	33,800	.1	3.1
181	1257	0320		18.8	34,851	.4	
182	1250	0445		18.5	34,602		
183	0833	0530		18.2	37,000		2.1
183	1303	0530		18.9	37,380		
184	0905	0600		18.0	36,480		4.2
184	1247	0600		18.9	36,500		
187	0835	0800		19.8	34,770	2.0	
187	1254	0800		19.9	32,800	1.1	
188	1305	0820		19.9	33,730	1.5	
188	0908	0820		19.7	33,946	1.7	4.3
189	0900	2150		19.8	36,462	1.9	3.2
189	1243	0915		19.9	37,931	2.8	
190	1252	0955		20.2	38,170	.8	
190	0853	2120		19.8	37,992	.4	2.4
191	1211	1040		20.8	27,131	.8	
194	0903	0120		21.5	34,450	.8	5.8
194	1257	0120		21.0	32,575	1.7	
195	0912	0130		20.6	23,760	1.4	5.9
195	1307	0130		20.4	30,485	1.0	
196	1354	0230		19.8	32,433	1.0	
196	0950	0230		20.1	17,080	3.1	3.2
197	0855	0330		19.0	26,910	1.4	4.8
197	1333	0330		19.8	29,940	.4	
198	1008	0440		19.8	32,433	.4	11.2
198	1359	0440		20.0	24,024	1.8	
201	0902	0725		21.7	29,940	1.6	2.5
201	1309	0725		22.7	21,865	1.6	
203	0952	0930		22.0	25,950	2.1	3.4
203	1330	0930		22.9	10,600	4.7	

STATION 28 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
204	1044	1015		22.4	28,620	2.0	
204	1246	1015		22.8	22,575	1.7	
205	1005	2315		22.1	23,333	2.1	3.3
205	1152	1115		21.9	31,390	1.4	
206	0912	2400		22.6	22,471	1.6	2.1
206	1341	1215		21.2	9,634	5.9	
209	1327	0230		21.3	35,510	.5	
209	0850	0230		22.2	18,020	3.3	3.5
210	1329	0315		22.3	33,552	.3	
210	0904	3155		23.2	24,204	1.4	3.1
211	1340	0415		22.3	31,161	.2	
211	0902	0415		21.9	33,670		3.6
214	0917	0600		20.6	34,820	.4	3.4
214	1308	0600		20.9	36,810		
215	0910	0710		19.7	40,333	.2	4.3
215	1312	0710		20.4	40,333		
216	0909	0730		20.0	40,333	.3	4.2
216	1325	0730		21.4	38,413		
217	0941	0830		19.7		1.0	4.9
217	1404	0830		19.7	37,231	1.1	
218	1215	0930		21.5	37,231	.2	3.2
218	1530	0930		21.3	37,090	.1	
219	1208	0945		20.5	38,720	1.2	2.0
219	1546	0945		21.4	37,520	.4	
222	0959			21.3	33,151		2.0
222	1338	1210		21.0	37,090	.5	
223	0910	0045		21.9	35,720		4.1
223	1310	0045		22.0	36,810		
224	0851	0130		21.8	35,852		2.8
224	1300	0130		22.4	35,985		
225	0855	0245		21.9	35,985		
225	1315	0245		22.6	36,530		

STATION 29 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1310	0845		20.0	35,800	1.0	
174	1414	0930		22.5	27,700	2.5	
174	0941	0930		20.0	26,160	2.0	
175	1313	1030		20.1	27,610	1.7	
175	0923	2215		18.5	30,150	1.5	
176	0824	2315		18.9	17,420	3.8	
176	1345	1130		18.6	27,270	1.3	
177	1051	2346		18.8	26,100	.5	
177	1245	1221		19.3	12,430	5.2	
180	0856	0227		18.3	8,360	6.9	
180	1238	0227		20.0	74,394	7.1	
181	0905	0320		20.3	26,934	1.2	
181	1315	0320		21.8	19,060	3.1	
182	0858	0445		17.8	31,661	.6	
182	1303	0445		20.3	15,580	4.7	
183	0841	0530		20.0	31,153	.6	
183	1312	0530		23.2	82,000	7.4	
184	1304	0600		21.2	26,180	2.5	
184	0919	0600		19.7	25,960	2.3	
187	0915	0800		21.0	25,130	2.8	
187	1315	0800		22.3	6,135	8.4	
188	0920	0820		21.2	24,460	3.9	
188	1321	0820		21.2	26,840	3.1	
189	0915	2150		21.4	27,224	3.1	
189	1302	0915		21.9	28,930	2.1	
190	0904	2120		23.8	7,157	7.3	
190	1307	0955		23.0	23,700	3.9	
191	0825	2330			5,861	8.0	
191	1216	1040		24.0	28,314	8.8	
194	0913	0120		22.7	8,203	7.9	
194	1309	0120		23.0	10,541	6.1	
195	0923	0130		21.5	2,576	7.7	
195	1315	0130		21.8	7,060	6.7	
196	0957	0230		19.9	5,094	7.2	
196	1405	0230		20.0	9,093	6.2	
197	0904	0330		19.1	12,025	6.5	
197	1341	0330		19.8	3,846	8.1	
198	1015	0440		21.6	6,200	7.1	
198	1410	0440		21.9	2,790	8.3	
201	0914	0725		22.4	13,704	4.7	
201	1317	0725		23.7	4,793	7.1	

STATION 29 TOP

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	1000	0930		23.6	324	8.9	
203	1339	0930		24.2	1,815	8.2	
204	1229	1015		25.6	7,572	6.6	
204	1058	1015		25.8	6,006	7.2	
205	1015	2315		23.9	1,960	7.6	
205	1141	1115		24.3	6,852	6.5	
206	0925	2400		22.7	2,305	7.5	
206	1356	1215		24.0	7,784	6.4	
209	0906	0230		24.4	45,900	7.4	
209	1340	0230		24.6	18,324	4.1	
210	1342	0315		26.1	3,150	8.2	
210	0915	0315		25.1	2,130	7.7	
211	0913	0415		25.0	35,000	7.0	
211	1350	0415		25.1	737	8.4	
214	1314	0600		22.9	13,444	6.5	
214	0928	0600		20.6	32,053	.1	
215	0920	0710		21.6	31,226	2.4	
215	1310	0710		21.9	25,474	4.2	
216	0916	0730		23.3	31,125	1.0	
216	1331	0730		24.1	10,300	8.1	
217	1412	0830		20.0	17,120	5.2	
217	0950	0830		19.8		.4	
218	1223	0930		22.0	26,162	3.4	
218	1537	0930		21.9	23,901	4.2	
219	1218	0945		21.8	26,593	3.5	
219	1553	0945		22.1	16,835	6.0	
222	1347	1210		21.8	17,664	5.2	
222	1010			21.6	16,632	5.0	
223	0918	0045		22.7	19,170	3.3	
223	1317	1315		23.7	18,333	4.4	
224	0901	0130		22.9	18,910	4.0	
224	1307	0130		24.3	23,160	3.0	
225	0901	0245		24.1	7,450	6.7	

STATION 29 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
173	1310	0845		18.0	26,900	3.0	
174	1416	0930		17.5	35,270	.8	
174	0943	0930		17.5	36,150	.5	
175	0925	2215		17.3	35,220	.4	
175	1315	1030		17.2	35,450	.1	
176	1347	1130		16.9	33,240	.4	
176	0826	2315		16.5	34,840	.2	
177	1247	1221		18.2	32,570		
177	1053	2346		18.0	33,280	.2	
180	0858	0227		16.6	37,150	.2	
180	1240	0227		17.8	34,100		
181	0907	0320		18.0	33,960		
181	1317	0320		19.2	33,800	.4	
182	0850	0445		17.1	35,450		.2
182	0900	0445		16.8	37,130		
182	1305	0445		18.2	34,250		
183	0842	0530		18.0	36,727		
183	1314	0530		18.9	35,570		
184	0921	0600		18.5	36,980		
184	1306	0600		18.2	38,314		
187	0917	0800		19.9	33,110	1.4	
187	1316	0800		21.8	12,343	6.3	
188	0921	0820		19.9	34,010	.2	
188	1323	0820		19.8	33,430		
189	0916	2150		19.8	34,830		
189	1304	0915		20.0	36,780	1.0	
190	1308	0955		20.1	36,232	.1	
190	0906	2120		19.7	37,736	.2	
191	0827	2330		21.2	33,771	.2	
191	1218	1040		20.8	2,420	.2	
194	0916	0120		21.3	34,205	.6	
194	1311	0120		21.3	29,076	.6	
195	0924	0130		21.9	16,510	3.2	
195	1317	0130		20.8	31,420	.3	
196	1406	0230		19.8	32,325	.5	
196	0958	0230		19.8	25,673	1.4	
197	0906	0330		19.2	25,770	2.7	
197	1343	0330		19.6	20,484	3.5	
198	1016	0440		20.0	18,720	4.4	
198	1412	0440		20.0	16,750	3.5	
201	0916	0725		21.5	27,331	.5	
201	1319	0725		21.7	23,112	.9	

STATION 29 BOTTOM

YEAR (DAYS) (1)	TIME OF DAY (HRS) (2)	TIDE (HRS) (3)	MPN 100 ML (4)	TEMP (C.) (5)	SPEC. COND. (U MHOS) (6)	DO (PPM) (7)	BOD (PPM) (8)
203	1002	0930		22.2	17,985	2.0	
203	1340	0930		23.6	5,121	7.2	
204	1231	1015		22.7	26,300	1.0	
204	1059	1015		24.3	6,401	6.5	
205	1017	2315		23.6	40,210	6.8	
205	1143	1115		22.4	24,325	1.3	
206	0926	2400		23.6	15,693	3.2	
206	1357	1215		22.3	27,370	1.4	
209	1342	0230		21.4	35,000		
209	0908	0230		22.7	11,940	5.2	
210	1343	0315		22.2	33,210	.3	
210	0916	0315		23.4	14,720	4.0	
211	0915	0415		24.0	19,460	1.2	
211	1352	0415		22.0	31,161		
214	0929	0600		20.4	36,255	.3	
214	1315	0600		21.8	31,531	.3	
215	0922	0710		19.9	39,672	.2	
215	1320	0710		20.0	37,812	.3	
216	0918	0730		20.4	40,166		
216	1333	0730		22.1	35,852	.2	
217	0951	0830		18.0	43,410	5.4	
217	1413	0830		20.0	28,895	1.8	
218	1224	0930		21.6	37,231	.2	
218	1539	0930		21.3	35,720	.2	
218	1539	0930		21.3	35,720	.2	
219	1219	0945		21.0	37,450		
219	1555	0945		21.3	37,374		
222	1012			21.3	34,695		
222	1348	1210		21.2	34,695		
223	0920	0045		21.6	35,852		
223	1318	1315		22.0	36,950		
224	0903	0130		21.6	36,120		
224	1309	0130		22.1	35,424		

APPENDIX B

TECHNICAL DETAILS

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APPENDIX B

TECHNICAL DETAILS

SECTION 1. MPN SAMPLING METHODS

1. Sampling methods used The convenient collection of depth samples suitable for analysis for the most probable number of coliform organisms has plagued water quality investigators for a considerable length of time. Various devices for obtaining samples from the deeper water layers have been proposed, all of which are predicated on the necessity of sterile sample containers. Some devices have an optimum depth, below which sample collection is difficult. Other means of sampling require extensive preliminary laboratory preparations such as glass bending, fitting and sterilization.

2. The results obtained in the MPN test are interpreted statistically. These results, depending on the number of tubes and dilutions employed, are subject to relatively wide variations in their accuracy. Consequently, it was felt that the rapid collection of depth samples by means of a standard water sampler would provide essentially the same results as the more tedious collection of samples by sterile means.

3. In order to support this contention, a number of duplicate samples were collected and analyzed for the MPN. The standard sampler used throughout the survey was a Foerst water sampler, a hybrid of the Nansen bottle used in oceanographic research. The first drawoff from the Foerst was used for the DO analysis, followed by a drawoff into a sterile tube. This portion was then iced in preparation for the MPN test.

4. The sterile sampler which was used is commonly known as the "broken tube" sampler. This device, by means of sterilized glass tubing and sample bottle, collects a sterile sample at any depth. At the selected depth, the tubing is broken by means of a brass messenger and water is free to flow into the bottle. Some exchange of water occurs during the withdrawal of the sampler, but this is extremely small.

5. Results At various stations both samplers were lowered simultaneously to the same depth, at which point the duplicate samples were collected. The results obtained from these duplicate samples are presented in Table B-1. The approximate 95% confidence limits for the MPN

TABLE B - 1

COMPARISON OF MPN RESULTS USING TWO DIFFERENT SAMPLERS

Sta. No.	Approx. Sample Depth (ft.)	MPN/100 ml.	
		Water Bottle	Sterile Sampler
1	15	3.6	3.6
		23	23
2	35	23	9
		23	15
3	30	39	750
		230	230
4	30	93	43
		93	460
5	5	11,000	930
6	30	11,000	93
		240	240
7	5	930	93
8	30	43	23
		39	23
9	5	23	3.6
	15	23	5
		9	23
10	15	21	9
		23	23
11	5	43	93
	20	23	23
12	5	43	240
	15	39	9
		20	39
13	5	43	23
	35	23	23
		9.1	3.6
14	5	23	9
	40	43	9
		3.6	15
15	5	14	9
	50	9	9

TABLE B - 1

(Continued)

Sta. No.	Approx. Sample Depth (ft.)	MPN/100 ml. Water Bottle	MPN/100 ml. Sterile Sampler
16	5	39	43
	30	75	23
		3.6	3.6
		3.6	3.6
17	5	93	93
	20	15	15
		15	9.1
18	5	460	43
	35	23	43
		15	9.1
19	5	7500	1100
	20	230	930

test using 3 tubes in each dilution as reported by Woodward[1] are 21% and 395% of the computed MPN. Inspection of this table indicates no specific bias of results toward one method of sampling. In order to verify this further, statistical tests were used in order to determine whether significant differences exist between the two methods of sampling. The geometric mean of the samples for the broken tube method was about 32 and for the water bottle was about 44. A "t" test performed on the difference between these means and the results indicates no apparent significant difference. It is concluded therefore that there is no difference between the MPN obtained by collecting samples either by the sterile sampler or by the standard water bottle. The results of the MPN analyses as presented in Appendix A can therefore be used as representing the best estimate of the MPN density at the time of sampling.

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[1] This and the following footnotes refer to respectively numbered entries in the Bibliography at the end of this Appendix.

SECTION 2. SINUSOIDAL ANALYSIS

6. General The description of the variations in water quality was accomplished by means of a three-cycle sinusoidal analysis. The analysis of one cycle sinusoidal variations of water quality characteristics originally proposed by Diachishin [2] and further extended in a study of the Delaware estuary [3] [4] was modified slightly for use in the study of the effects of the proposed hurricane barriers in Narragansett Bay. The major modifications consist of altering the periods of the three cycles.

7. Equation For the assumed three-cycle variation, the general fitting equation has been assumed to have the form:

$$\text{(i)}\quad Y = Y_m + Y_{aa} \sin \frac{t_a - t_{oa}}{P_a} + Y_{ae} \sin \frac{t_e - t_{oe}}{P_e} + Y_{at} \sin \frac{t_t - t_{ot}}{P_t}$$

where:

Y = any water quality variable (e. g. temp., dissolved oxygen, etc.)

t_a = time of year sample was collected (days)

P_a = period of assumed annual cycle = 365 days

t_e = difference between time sample was collected and the time of the last new moon (days)

P_e = period of assumed lunar cycle = 29.5 days

t_t = difference between time sample was collected and the time of the last high tide (hours)

P_t = period of assumed tidal cycle = 12.42 hours

and Y_m, Y_{aa}, Y_{ae}, Y_{at}, t_{oa}, t_{oe}, and t_{ot} = constants to be solved for.

8. The above three cycles were initially assumed as representing the major portion of the variation of water quality. The form of equation (i) is not amenable for solution and a trigonometric identity is used which, by suitable substitution, yields:

$$\text{(ii)}\quad Y = Y_m + Y_1 \sin \frac{t_a}{P_a} + Y_2 \sin \frac{t_e}{P_e} + Y_3 \sin \frac{t_t}{P_t} + Y_4 \cos \frac{t_a}{P_a} + Y_5 \cos \frac{t_e}{P_e} + Y_6 \cos \frac{t_t}{P_t}$$

where:

$$\text{(iia)}\quad Y_{1,2,3} = Y_{aa,e,t} \cos \frac{t_{oa,e,t}}{P_{a,e,t}}$$

$$\text{(iib)}\quad Y_{4,5,6} = Y_{aa,e,t} \sin \frac{t_{oa,e,t}}{P_{a,e,t}}$$

9. In order to determine the constants of equation (ii) by utilizing the observed data, the method of least squares is performed. Hence, partial differentiation of (ii) yields a system of seven "normal" equations, the simultaneous solution of which yields the constants. Once the coefficients are obtained, either equation (i) or (ii) can be used to determine the estimated value of Y. The use of equation (i) for this purpose necessitates the simultaneous solutions of (iia) and (iib).

10. Physical implications of final descriptive equation Inspection of equation (i) indicates that the constants for each sine term, e. g. Y_{ae} and t_{oe} represent respectively the amplitude and phase angle of the cycle. Physically, then, the determination of these constants is desirable in order to determine the maximum deviation from the mean amplitude as well as the point in time at which the positive portion of the sine curve begins (phase angle). However, these constants lose their physical meaning for cycles which have been sampled predominately during one time period. Such is the case with respect to the water quality study of Narragansett Bay made during June-August of 1959. The survey covered only two months of a twelve month cycle. Hence, the extrapolation of values outside the limits of the survey has little meaning; but within the time limits of the survey, the determination of either equation (i) or (ii) allows the interpolation of values with a sufficient degree of accuracy.

11. The significance of the equation and of the coefficients obtained can be determined by a variety of statistical tests. A discussion of the use of these tests is beyond the scope of this report. Primarily, however, the results of the Analysis of Variance (ANOVA) for each regression analysis together with the standard errors of the partial regression coefficients (the constants of the equations) have been used to determine the final form of the descriptive euqation.

12. Table B-2 presents the multiple correlation coefficients obtained by use of the sinusoidal equation discussed above. In order to determine the statistical significance of the final equation, the Fischer Ratio test was applied to the regression and residual variances with their appropriate degrees of freedom. Where the F-test indicated a level of significance greater than about 10%, the results of the equation were assumed to be non-significant and no variation during the three time cycles was assumed to occur. In general, for stations #1 to #19, a

TABLE B-2

MULTIPLE CORRELATION COEFFICIENTS FROM THREE CYCLE SINUSOIDAL ANALYSES

Station Number	Specific Conductance		Temperature		D. O.		Log MPN	
	Sur.	Bot.	Sur.	Bot.	Sur.	Bot.	Sur.	Bot.
1	0.46	0.64	0.83	0.81	0.66	0.82	0.22	0.59
2	0.80	0.37	0.82	0.75	0.68	0.90	0.63	0.51
3	0.82	0.64	0.76	0.75	0.63	0.87	0.37	0.48
4	0.84	0.50	0.81	0.71	0.72	0.85	0.65	0.62
5	0.84	-	0.81	-	0.61	-	0.62	-
6	0.57	0.51	0.88	0.73	0.71	0.76	0.67	0.63
7	0.88	-	0.61	-	0.57	-	0.70	-
8	0.80	0.70	0.79	0.77	0.68	0.73	0.68	0.63
9	0.40	0.58	0.78	0.83	0.55	0.71	0.45	0.67
10	0.94	0.35	0.72	0.85	0.83	0.73	0.52	0.58
11	0.78	0.58	0.84	0.84	0.58	0.78	0.31	0.66
12	0.80	0.53	0.83	0.88	0.62	0.74	0.33	0.69
13	0.77	0.58	0.78	0.81	0.47	0.86	0.46	0.66
14	0.78	0.58	0.73	0.64	0.80	0.61	0.66	0.45
15	0.51	0.64	0.78	0.69	0.52	0.88	0.45	0.48
16	0.63	0.58	0.78	0.65	0.66	0.97	0.45	0.54
17	0.59	0.53	0.76	0.69	0.72	0.95	0.55	0.58
18	0.64	0.32	0.78	0.79	0.66	0.94	0.50	0.45
19	0.72	0.65	0.79	0.73	0.78	0.88	0.36	0.52
20	0.87	0.59	0.73	0.88	0.58	0.58		
21	0.62	0.40	0.80	0.93	0.46	0.65		
22	0.56	0.61	0.84	0.77	0.44	0.66		
23	0.64	0.63	0.68	0.85	0.54	0.68		
24	0.83	0.76	0.75	0.85	0.66	0.57		
25	0.87	0.57	0.73	0.84	0.77	0.59		
26	0.82	0.71	0.75	0.87	0.76	0.68		
27	0.81	0.61	0.74	0.89	0.77	0.71		
28	0.74	0.61	0.74	0.88	0.75	0.66		
29	0.63	0.69	0.68	0.85	0.76	0.57		

TABLE B-3

COMPUTED VALUES OF SURFACE CHLORIDE VARIATIONS AT DIFFERENT TIMES OF TIDAL AND LUNAR CYCLE

(All Values in Parts per Thousand)

Station Number	Survey Average	Variation Around Survey Average Due to Time of Tide				Variation Around Survey Average Due to Time of Lunar Month			
		HW 0.0	HW 3.1	HW 6.2	HW 9.3	New Moon	First Quarter	Full Moon	Last Quarter
1	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3
2	15.8	16.0	15.8	15.7	15.9	15.8	16.3	15.8	15.3
3	13.0	13.5	13.5	12.5	12.5	14.1	14.0	11.9	12.0
4	13.8	14.5	14.4	13.2	13.8	14.6	14.6	13.2	13.2
5	14.8	14.8	14.8	14.8	14.8	15.3	15.7	14.3	14.0
6	14.5	14.7	14.2	14.2	14.6	15.1	15.1	13.7	13.7
7	14.8	15.1	14.9	14.4	14.5	15.3	15.3	14.7	14.7
8	14.8	15.1	14.5	14.4	14.9	15.2	15.5	14.3	14.0
9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9
10	15.1	15.2	15.4	15.0	14.8	15.7	15.8	14.4	14.3
11	15.2	15.4	15.5	15.0	14.9	15.6	15.8	14.8	14.6
12	15.5	15.6	15.7	15.5	15.3	15.7	16.2	15.3	14.8
13	15.7	15.6	15.7	15.7	15.7	15.9	16.1	15.5	15.2
14	16.3	16.6	16.3	15.8	16.2	16.3	16.6	16.3	16.0
15	16.0	16.8	16.0	15.1	15.9	15.8	16.5	16.2	15.4
16	15.7	16.2	15.6	15.3	15.8	15.7	15.7	15.7	15.7
17	15.3	15.8	15.1	14.6	15.3	15.3	15.8	15.7	14.8
18	15.6	16.0	15.4	15.2	15.8	15.6	16.0	15.6	14.8
19	14.2	14.4	14.3	14.0	14.1	14.7	14.7	13.7	13.7
20	11.3	11.3	11.7	11.4	11.0	13.1	12.3	9.5	10.2
21	11.3	10.9	12.0	11.6	10.6	13.0	12.3	9.5	10.4
22	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7
23	9.9	10.7	9.3	9.2	10.6	11.5	11.2	8.2	8.6
24	9.1	10.8	7.5	7.4	10.6	11.2	10.8	7.0	7.3
25	7.7	9.0	5.4	6.4	9.9	10.3	10.0	4.9	5.3
26	6.9	7.3	6.9	6.3	6.7	9.3	9.2	4.3	4.4
27	6.8	6.8	6.8	6.8	6.8	9.1	8.2	3.4	4.4
28	4.8	4.1	6.0	5.5	3.6	7.7	6.1	2.0	3.6
29	5.6	5.4	7.4	5.8	4.1	8.6	4.8	2.6	6.5

TABLE B-4

COMPUTED VALUES OF BOTTOM CHLORIDE VARIATIONS AT DIFFERENT TIMES OF TIDAL AND LUNAR CYCLE

(All Values in Parts per Thousand)

Station Number	Survey Average	Variation Around Survey Average Due to Time of Tide				Variation Around Survey Average Due to Time of Lunar Month			
		HW 0.0	HW 3.1	HW 6.2	HW 9.3	New Moon	First Quarter	Full Moon	Last Quarter
1	16.1	15.9	16.2	16.4	16.2	16.3	16.3	16.0	16.0
2	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4
3	16.1	16.2	16.5	16.2	15.9	16.7	16.4	15.6	16.0
4	16.2	16.2	16.2	16.2	16.2	16.8	16.3	15.5	16.0
5	-	-	-	-	-	-	-	-	-
6	16.8	16.8	16.8	16.8	16.8	17.5	17.3	16.4	16.6
7	-	-	-	-	-	-	-	-	-
8	16.6	16.5	16.5	16.9	16.8	17.3	16.6	16.2	16.8
9	16.4	16.2	16.4	16.2	16.1	16.4	16.4	16.2	16.2
10	16.5	17.0	15.2	16.1	18.1	16.6	15.3	16.6	18.0
11	16.3	16.5	16.3	16.0	16.2	16.3	16.3	16.3	16.3
12	16.3	16.3	16.3	16.3	16.3	16.2	16.5	16.2	16.0
13	17.3	17.3	17.5	17.5	17.3	17.6	17.4	17.3	17.5
14	17.2	17.3	16.9	17.2	17.5	17.5	17.4	16.9	17.1
15	17.0	17.2	16.8	16.8	17.2	17.3	17.2	16.7	16.8
16	16.7	16.8	16.5	16.4	16.5	17.4	16.6	15.8	16.6
17	17.2	17.5	17.3	17.0	17.2	17.5	16.9	16.9	17.5
18	16.2	17.5	15.3	15.0	16.9	16.2	16.2	16.2	16.2
19	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
20	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8
21	15.9	15.9	15.9	15.9	15.9	16.4	16.0	15.5	15.9
22	14.7	14.8	14.3	14.8	15.0	15.0	14.5	14.5	15.0
23	14.0	14.3	12.3	13.5	15.5	15.2	13.5	12.8	14.5
24	13.4	14.8	11.7	11.6	14.8	14.5	13.0	12.0	13.5
25	12.6	13.4	11.3	11.8	13.9	14.1	12.8	11.2	12.5
26	11.7	12.8	11.6	10.6	11.7	13.9	11.5	9.5	11.8
27	12.0	13.4	12.2	10.6	11.7	14.7	11.9	9.8	12.2
28	11.6	12.7	11.8	10.6	11.4	14.6	12.0	8.8	11.3
29	10.8	11.6	10.8	9.8	10.3	13.3	10.8	8.9	10.9

TABLE B-5

COMPUTED VALUES OF SURFACE TEMPERATURE VARIATIONS AT DIFFERENT TIMES OF TIDAL AND LUNAR CYCLE

(All Values in ^{o}C.)

Station Number	Survey Average	Variation Around Survey Average Due to Time of Tide				Variation Around Survey Average Due to Time of Lunar Month			
		HW 0.0	HW 3.1	HW 6.2	HW 9.3	New Moon	First Quarter	Full Moon	Last Quarter
1	20.4	19.3	21.0	21.5	19.8	19.7	20.7	21.1	20.1
2	19.7	19.4	19.5	20.0	19.9	19.7	19.7	19.7	19.7
3	21.2	20.6	20.8	21.8	21.6	21.2	21.2	21.2	21.2
4	20.8	19.9	20.1	21.7	21.5	20.3	20.5	21.3	21.1
5	20.7	20.2	20.4	21.1	20.9	20.0	20.0	21.4	21.3
6	20.7	20.6	20.3	20.8	21.1	20.2	20.2	21.3	21.2
7	20.8	20.6	20.1	21.0	21.5	20.8	20.8	20.8	20.8
8	20.6	22.0	21.7	22.4	22.7	20.2	20.1	21.1	21.1
9	20.6	20.2	19.8	21.0	21.3	20.0	20.1	21.2	21.0
10	21.0	20.8	20.4	21.2	21.8	21.0	21.0	21.0	21.0
11	21.1	21.0	21.0	21.1	22.1	20.5	20.1	21.6	22.1
12	20.8	21.0	19.9	20.7	21.7	20.5	19.9	21.2	21.7
13	20.8	21.0	19.9	20.5	21.6	20.8	20.8	20.8	20.8
14	20.0	19.4	19.5	20.4	20.4	20.0	20.0	20.0	20.0
15	19.8	19.4	19.0	20.2	20.7	19.5	19.0	21.1	20.6
16	20.9	21.2	20.2	20.5	21.6	20.8	20.1	20.9	21.7
17	21.8	22.3	21.2	21.3	22.4	21.6	20.8	22.0	22.7
18	21.0	21.5	20.5	20.6	21.5	21.0	21.0	21.0	21.0
19	22.1	23.3	20.8	20.9	23.4	21.7	21.2	22.4	23.0
20	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
21	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
22	21.9	21.9	21.9	21.9	21.9	21.0	20.9	22.7	22.8
23	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4
24	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4
25	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7
26	22.0	22.0	21.5	21.6	22.0	22.0	22.0	22.0	22.0
27	22.1	22.2	21.7	22.0	22.4	22.1	22.1	22.1	22.1
28	22.2	22.4	21.6	21.9	22.6	22.2	22.2	22.2	22.2
29	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0

TABLE B-6

COMPUTED VALUES OF BOTTOM TEMPERATURE VARIATIONS AT DIFFERENT TIMES OF TIDAL AND LUNAR CYCLE

(All Values in °C.)

Station Number	Survey Average	Variation Around Survey Average Due to Time of Tide				Variation Around Survey Average Due to Time of Lunar Month			
		HW 0.0	HW 3.1	HW 6.2	HW 9.3	New Moon	First Quarter	Full Moon	Last Quarter
1	19.4	18.9	19.4	19.9	19.4	18.9	19.5	20.0	19.4
2	18.9	18.9	18.9	18.9	18.9	18.0	18.8	19.7	19.0
3	18.6	18.6	18.6	18.6	18.6	17.8	18.9	19.4	18.4
4	18.6	18.5	18.3	18.6	18.8	18.0	18.7	19.1	18.4
5	-	-	-	-	-	-	-	-	-
6	18.5	18.5	18.5	18.5	18.5	17.6	18.4	19.4	18.6
7	-	-	-	-	-	-	-	-	-
8	17.8	17.8	17.5	17.8	18.0	17.2	18.0	18.4	17.6
9	19.3	19.1	18.7	19.5	19.8	19.3	19.3	19.3	19.3
10	19.7	19.2	19.7	20.3	19.8	19.7	19.7	19.7	19.7
11	19.7	19.7	18.8	19.7	20.6	19.7	19.7	19.7	19.7
12	19.3	19.3	18.4	19.2	20.1	19.3	19.3	19.3	19.3
13	18.5	18.9	17.8	18.2	19.3	18.0	18.6	19.1	18.5
14	17.5	17.5	18.2	17.4	16.6	17.5	17.5	17.5	17.5
15	17.7	17.7	17.7	17.7	17.7	17.1	17.9	18.4	17.6
16	18.4	18.7	18.0	18.1	18.8	18.0	18.9	18.8	17.9
17	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1
18	19.5	20.1	19.1	18.9	20.0	19.0	19.8	20.0	19.2
19	20.0	20.9	19.6	19.1	20.4	19.3	19.9	20.7	20.1
20	18.3	18.3	18.3	18.3	18.3	17.4	18.4	19.2	18.3
21	18.3	18.2	18.2	18.4	18.4	18.3	18.3	18.3	18.3
22	19.7	19.8	20.3	19.7	19.2	19.1	19.9	20.4	19.5
23	19.4	19.4	19.4	19.4	19.4	18.7	19.7	20.1	19.1
24	19.8	19.3	20.2	20.3	19.4	19.1	19.8	20.0	19.8
25	19.9	19.9	20.3	20.0	19.5	19.3	20.1	20.6	19.8
26	20.3	20.2	20.1	20.3	20.4	19.6	20.2	20.9	20.3
27	20.2	20.2	20.0	20.2	20.4	19.6	20.1	20.8	20.3
28	20.4	20.4	20.4	20.4	20.4	19.8	20.3	20.9	20.5
29	20.4	20.4	20.4	20.4	20.4	19.8	20.2	20.9	20.6

TABLE B-7

COMPUTED VALUES OF SURFACE DISOOLVED OXYGEN VARIATIONS AT DIFFERENT TIMES OF TIDAL AND LUNAR CYCLE

(All Values in Parts Per Million)

Station Number	Survey Average	Variation Around Survey Average Due to Time of Tide				Variation Around Survey Average Due to Time of Lunar Month			
		HW 0.0	HW 3.1	HW 6.2	HW 9.3	New Moon	First Quarter	Full Moon	Last Quarter
1	6.74	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
2	6.54	6.5	6.5	6.5	6.5	7.0	6.0	6.0	7.0
3	5.74	5.8	4.5	5.6	6.9	7.2	4.7	4.3	6.8
4	6.13	6.7	5.3	5.5	6.9	7.2	5.2	5.1	7.1
5	7.49	7.7	6.2	7.3	8.8	7.5	7.5	7.5	7.5
6	7.26	7.7	6.4	6.8	8.2	8.2	6.2	6.3	8.3
7	7.44	8.0	6.5	6.8	8.4	7.4	7.4	7.4	7.4
8	7.40	8.2	7.3	6.6	7.5	7.7	6.6	7.2	8.3
9	7.66	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
10	6.84	8.7	6.2	5.0	7.4	6.8	6.7	6.9	7.0
11	7.52	7.3	6.2	7.7	8.8	7.5	7.0	7.6	8.0
12	8.09	8.2	7.2	8.0	9.0	8.4	7.4	7.8	8.8
13	8.18	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2
14	7.64	7.9	7.3	7.4	8.0	7.5	7.4	7.7	7.9
15	7.34	7.3	7.3	7.3	7.3	6.9	7.2	7.8	7.5
16	7.68	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
17	8.16	8.4	8.3	7.9	8.0	8.0	7.2	8.3	9.1
18	8.06	8.1	8.1	8.1	8.1	7.8	7.4	8.3	8.7
19	6.84	8.6	6.3	5.0	7.4	6.3	6.0	7.4	7.6
20	4.51	4.5	4.5	4.5	4.5	6.1	3.8	3.0	5.2
21	3.87	4.3	3.4	3.6	4.2	4.6	3.6	3.1	4.2
22	3.59	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
23	3.62	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
24	3.39	3.4	3.4	3.4	3.4	4.3	3.8	2.5	3.0
25	3.58	3.8	4.5	3.3	2.6	3.7	3.9	3.5	3.3
26	3.32	3.6	3.5	3.1	3.2	3.3	3.3	3.3	3.3
27	3.45	3.4	3.4	3.4	3.4	2.8	3.8	4.1	3.1
28	4.44	4.6	3.9	4.2	5.0	4.4	4.4	4.4	4.4
29	4.99	4.4	3.8	5.6	6.2	4.0	4.8	6.0	5.2

TABLE B-8

COMPUTED VALUES OF BOTTOM DISSOLVED OXYGEN VARIATIONS AT DIFFERENT TIMES OF TIDAL AND LUNAR CYCLE

(All Values in Parts Per Million)

Station Number	Survey Average	Variation Around Survey Average Due to Time of Tide				Variation Around Survey Average Due to Time of Lunar Month			
		HW 0.0	HW 3.1	HW 6.2	HW 9.3	New Moon	First Quarter	Full Moon	Last Quarter
1	4.50	5.0	3.9	4.0	5.1	4.3	5.1	4.7	3.9
2	4.95	5.4	4.3	4.6	5.6	4.7	4.4	5.2	4.4
3	3.53	3.5	3.5	3.5	3.5	3.0	3.5	4.0	3.6
4	4.10	4.1	3.7	4.1	4.5	3.9	4.2	4.4	4.0
5	-	-	-	-	-	-	-	-	-
6	4.35	4.0	3.5	4.8	5.2	4.1	5.3	4.6	3.4
7	-	-	-	-	-	-	-	-	-
8	4.83	4.8	4.8	4.8	4.8	4.5	4.7	5.2	5.0
9	4.74	5.0	4.9	4.5	4.6	4.7	4.7	4.7	4.7
10	5.00	5.5	5.2	4.5	4.8	5.0	5.0	5.0	5.0
11	5.36	5.2	5.9	5.5	4.8	5.4	5.4	5.4	5.4
12	5.49	6.1	5.8	4.9	5.2	5.2	5.7	5.7	5.3
13	5.54	6.0	5.7	5.1	5.4	5.3	6.0	5.8	5.1
14	6.49	6.8	6.4	6.1	6.6	6.3	6.6	6.7	6.4
15	6.28	6.5	6.3	6.1	6.2	6.2	6.2	6.4	6.4
16	5.86	6.1	6.0	5.6	5.7	5.5	5.8	6.2	5.8
17	5.56	6.0	5.8	5.2	5.8	5.2	5.3	6.9	5.8
18	5.60	5.8	5.8	5.4	5.4	5.3	5.9	5.9	5.3
19	4.75	4.8	4.9	4.6	4.6	4.5	4.8	5.0	4.6
20	1.99	2.0	2.0	2.0	2.0	1.7	1.9	2.3	2.1
21	1.40	1.4	1.4	1.4	1.4	1.2	1.3	1.6	1.5
22	1.77	2.0	2.0	2.0	1.5	1.8	1.8	1.8	1.8
23	1.81	2.0	1.8	1.7	1.8	1.8	1.8	1.8	1.8
24	1.80	1.9	2.1	1.7	1.5	1.8	1.8	1.8	1.8
25	1.70	2.3	2.1	1.1	1.3	1.9	1.3	1.5	1.1
26	1.48	1.9	1.9	1.0	1.1	1.2	2.0	1.7	0.9
27	1.06	1.4	0.7	1.5	0.6	0.7	1.4	1.5	0.7
28	0.89	1.0	1.3	0.8	0.5	0.4	0.9	1.4	0.9
29	1.13	0.7	1.4	1.6	0.9	0.0	0.9	2.2	1.4

TABLE B-9

COMPUTED VALUES OF SURFACE MPN VARIATIONS AT DIFFERENT TIMES OF TIDAL AND LUNAR CYCLE

(All Values in MPN/100 ml to nearest 10 MPN/100 ml)

Station Number	Survey Average*	Variation Around Survey Average Due to Time of Tide				Variation Around Survey Average Due to Time of Lunar Month			
		HW 0.0	HW 3.1	HW 6.2	HW 9.3	New Moon	First Quarter	Full Moon	Last Quarter
1	20	20	20	20	20	20	20	20	20
2	50	70	170	40	20	10	10	20	20
3	2260	2260	2260	2260	2260	2260	2260	2260	2260
4	1910	340	5360	10,700	6600	1910	1910	1910	1910
5	260	180	560	400	130	260	260	260	260
6	380	100	530	1510	180	380	380	380	380
7	230	50	220	1200	250	230	230	230	230
8	180	70	500	430	60	180	180	180	180
9	80	50	100	140	80	80	80	80	80
10	80	110	110	60	60	80	80	80	80
11	40	40	40	40	40	40	40	40	40
12	70	70	70	70	70	70	70	70	70
13	45	30	50	70	40	40	40	40	40
14	25	20	40	40	20	70	30	10	20
15	40	40	40	40	40	40	40	40	40
16	45	30	80	100	30	40	40	40	40
17	140	70	120	280	170	140	250	140	80
18	140	100	220	190	90	140	140	140	140
19	1240	1240	1240	1240	1240	1240	1240	1240	1240

* Geometric Average

TABLE B-10

COMPUTED VALUES OF BOTTOM MPN VARIATIONS AT DIFFERENT TIMES OF TIDAL AND LUNAR CYCLE

(All Values in MPN/100 ml to nearest 5 MPN/100 ml)

Station Number	Survey Average*	Variation Around Survey Average Due to Time of Tide				Variation Around Survey Average Due to Time of Lunar Month			
		HW 0.0	HW 3.1	HW 6.2	HW 9.3	New Moon	First Quarter	Full Moon	Last Quarter
1	10	15	30	10	5	10	10	10	10
2	15	10	40	20	5	15	15	15	15
3	210	210	210	210	210	210	210	210	210
4	105	40	320	275	35	105	105	105	105
5	-	-	-	-	-	-	-	-	-
6	60	40	175	100	20	60	60	60	60
7	-	-	-	-	-	-	-	-	-
8	30	10	50	40	30	30	30	30	30
9	30	20	45	50	20	15	25	60	40
10	20	10	35	40	15	20	20	20	20
11	20	5	30	45	10	5	15	50	20
12	20	5	30	60	10	10	15	35	25
13	10	5	15	20	10	10	10	10	10
14	10	10	10	10	10	10	10	10	10
15	15	15	15	15	15	10	10	10	10
16	10	10	10	20	10	5	15	30	10
17	15	5	15	35	15	15	15	15	15
18	50	45	30	55	95	50	50	50	50
19	90	105	50	80	160	90	90	90	90

* Geometric Average

correlation coefficient of less than about 0.40 produced a significance level greater than 10%. For stations #20 to #29, a correlation coefficient of about 0.35 produced a significance level greater than 10%. These guides can be used in the interpretation of the coefficients given in Table B-2.

13. Once the significance of the final equation was determined, statistical investigations were made into the significance of each of the regression coefficients. This was done by examining the "t" value for each coefficient. The results of this statistical test determined whether a particular variable can be considered to vary significantly (in a statistical sense) over a given time cycle. These determinations resulted in the compilation of Table 6 in the main body of the report and Tables B-3 through B-10 in this Appendix. Where there is no variation over either the tidal or lunar cycle, the application of the "t" test for the individual regression coefficients indicated a non-significant value.

14. In addition, the nature of the residual dissolved oxygen (observed value minus the calculated value) was investigated at five locations (station #2, surface, #4, surface, #8, surface, #17, surface, and #27, surface). The residual variation was tested for a normal distribution by means of the Chi-square test. These tests indicated that except for station #27, surface, the probability was 0.50 or greater that the residual variations formed a normal distribution. At #27, surface, the residual variations did not appear to follow a normal distribution.

SECTION 3

AUTOCOVARIANCE AND POWER SPECTRUM ANALYSES

15. General The computation of the autocovariance function and subsequent power spectral estimates has found increasing use in a variety of scientific fields. The most extensive use of this type of analysis has been in the field of communications engineering. Time and fund limitations prevented a more complete study to determine more precisely the power spectral estimates, since considerably more data and considerably increased computational efforts would have been required. The estimates presented in this report are somewhat crude, being based on limited and "broken" time series. However, they serve to substantiate or invalidate certain possible conclusions, and within the analysis itself other general conclusions can be made.

16. Form of equation used It is not pertinent in a report of this type to discuss the theoretical background or derivations of the autocovariance and power spectrum analyses. Rather, the formulae for the computation of both are given and the physical implications are discussed. The theoretical details are given in other publications. [5] [6] [7]

17. The autocovariance function represents the correlation of a time series with itself at some later time, lagged from the original series by an amount τ. If $Y(t)$ is the original time series and $R_y(\tau)$ are the coefficients determined by lagging $Y(t)$ by an amount τ, then $R_y(\tau)$ can be considered to be related to the "ordinary" correlation coefficients used in statistics to measure the relationship between two variables. In the case of autocovariance, $Y(t)$ at time t assumes the role of one variable and $Y(t)$ at time $t+\tau$ assumes the role of the other variable. The autocovariance function is given by:

$$\text{(i)} \quad R_y(\tau) = \frac{1}{(N-1) - \tau} \sum_{t=0}^{t=(N-1)-\tau} Y_t \cdot Y_{t+\tau}$$

for $\tau = 0,1,2\ldots m$

where:

Y_t = discrete point of variable Y at time t in terms of deviation from the mean

N = total number of discrete data points

M = maximum length of time lag

18. The value of m depends in some part on the length of record available and the spacing, in time, of the data points. It can now be seen that the prerequisite for the computation of the autocovariance function is that the data be spaced at equal time intervals. In the case of the Narragansett Bay data, this requirement was not completely fulfilled. The missing data was interpolated on a straight line basis between existing data in order to provide continuous discrete data points at equal intervals. This undoubtedly affects the computations to a considerable degree but as pointed out above, these analyses were used primarily to supplement the other analyses performed.

19. The power spectrum of the time series is given by a Fourier transform of the autocovariance function:

$$\text{(ii)}\quad B_i = \frac{R_y(0)}{m} + \frac{2}{m} \sum_{\tau=1}^{\tau=m-1} \left[R_y(\tau) \cos \frac{\pi}{m}(i\tau) + \frac{R_y(\tau=m)}{m} (-1)^i \right]$$

$$B_0 = \frac{B_i = 0}{2}, \quad B_m = \frac{B_i = m}{2}$$

where $B = i^{th}$ power spectral estimate and the remaining notation is as previously defined. Equation (ii) provides so-called "raw" unfiltered estimates. These estimates must be corrected for the finite length of record and for the discrete data points since the theoretical development assumes a continuous record of infinite length. The "smoothed" estimates are given by:

$$\text{(iii)}\quad U_i = .25B_{i-1} + .50B_i + .25B_{i+1}$$

$$U_0 = .50B_0 + .50B_1$$

$$U_m = .50B_m + .50B_{m-1}$$

20. The dimensions of the U_i's are given in variance per cycle per time. Hence, a power spectral estimate for log MPN during the survey would have the dimensions of log MPN/cycle/36 days for a chosen maximum lag m of 18 days. With the ordinate given in variance per frequency, and the abscissa in frequency, it can be seen that the area under the spectral curve is equal to the total variance of the original time series.

21. Since the computation of the smoothed power spectrum is only an estimate of the "true" power spectrum, it carries certain confidence limits. It can be shown that the form of the power spectrum function

can be approximated by a Chi-square distribution. The confidence limits can be determined from:

$$F = \frac{N - .25m}{.50m}$$

where f are the degrees of freedom. Given f, the use of a Chi-square statistical table allows the computation of any desired band of confidence limits.

22. Cross-correlation functions As mentioned in the body of the report, several cross-correlation plots were also obtained. The notion of autocovariance carries directly into cross-correlation, which represents the correlation of one variable X at time t with another variable Y at time $t + \tau$. Various significant statements can be made on the basis of the cross-correlation function and these have been discussed in the main body of the report. In addition, the concept of the power spectrum for a given variable also applies to cross power spectra between two variables. However, due to time limitations, power spectra between variables (or also between stations for the same variable) could not be computed for inclusion in this report.

23. Summary With the sinusoidal analysis and the results of the autocovariance and power spectrum analyses (although these were somewhat crude, due to a lack of sufficient length of data) it is felt that a fairly accurate description of the variations in water quality is obtained. Although all "odd" occurrences have not been explained by these analyses, as performed in the Narragansett data, sufficient insight into the mechanisms operating in the Bay has resulted.

SECTION 4. RELATIONSHIP BETWEEN TWO SINUSOIDAL FUNCTIONS

24. General relationship Using two one cycle sinusoidal functions with time as the parameter, the general relationships between the two variables can be determined as follows:

$$\text{(i)} \quad X = K_1 + K_2 \sin \frac{t - t_{oy}}{p} = K_1 + K_2 \sin \left(\frac{t}{p} - \frac{t_{ox}}{p}\right)$$

$$\sin \left(\frac{t}{p} - \frac{t_{ox}}{p}\right) = \frac{X - K_1}{K_2} = \alpha$$

$$\text{(ii)} \quad \frac{t}{p} = \text{arc} \sin \alpha + \frac{t_{oy}}{p}$$

25. Substituting (ii) into sinusoidal function of Y and using the trigonometric identity for the sine of the sum of two angles yields:

$$Y = K_3 + K_4 \sin \left(\frac{t}{p} - \frac{t_{oy}}{p}\right)$$

$$Y = K_3 + K_4 \sin \left(\text{arc} \sin \alpha + \frac{t_{oy}}{p} - \frac{t_{ox}}{p}\right)$$

$$\mu = \sin (\text{arc} \sin \alpha) \cos \beta + \cos (\text{arc} \sin \alpha) \sin \beta$$

where $\beta = \frac{t_{ox}}{p} - \frac{t_{oy}}{p}$

$$\mu = \frac{Y - K_3}{K_4}$$

or $\mu = \left[\alpha \cos \beta + \cos (\text{arc} \cos \sqrt{1 - \alpha^2}) \sin \beta\right]$

$$\text{(iii)} \quad \mu = \alpha \cos \beta + \sqrt{1 - \alpha^2} \sin \beta$$

26. Phase angles equal With phase angles equal, $t_{ox} = t_{oy}$ and $\sin \beta = 0$, $\cos \beta = 1$. Substituting into (iii) gives:

$$\frac{Y - K_3}{K_4} = \frac{X - K_1}{K_2}$$

or $\text{(iv)} \quad Y - K_3 = \frac{K_4}{K_2} (X - K_1)$

Equation (iv) is that of a straight line with slope given by K_4/K_2 (ratio of amplitudes) and passing through the points K_1 and K_3.

27. Phase angles 180° out of phase For $\beta = 180°$, $\sin \beta = 0$ and $\cos \beta = -1$ and the relationship is:

$$\frac{Y - K_3}{K_4} = \frac{-X - K_1}{K_2}$$

or (v) $$Y - K_3 = \frac{-K_4}{K_2}(X - K_1)$$

Equation (v) again has the form of a straight line with negative slope.

28. Phase angles 90° or 270° out of phase For $\beta = 90°$, $\sin \beta = 1$ and $\cos \beta = 0$ and the relationship is:

$$\frac{Y - K_3}{K_4} = \sqrt{1 - \alpha^2}$$

Squaring yields:

$$\frac{(Y - K_3)^2}{{K_4}^2} = 1 - \frac{(X - K_1)^2}{{K_2}^2}$$

or (vi) $$\frac{(Y - K_3)^2}{{K_4}^2} + \frac{(X - K_1)^2}{{K_2}^2} = 1$$

Equation (vi) is an equation for an ellipse with center at K_1 and K_3 and axes parallel to the original axes and of lengths K_4 and K_2. A similar substitution can be made for $\beta = 270°$ and equation (vi) will again result.

29. Remaining phase angle relationships The actual form of the equation for the remaining phase angle differences was not determined; rather, geometrical relationships were used to indicate that an eliptical function would result. Squaring both sides of (iii) recognizing $\sin^2\beta + \cos^2\beta = 1$, and collecting terms yields:

(vii) $$\gamma^2 - 2\gamma\alpha \cos\beta + \alpha^2 - \sin^2\beta = 0$$

Equation (vii) is in form:

$$Ax^2 + Bxy + Cy^2 + D = 0$$

For (vii) to be eliptical, $B^2 - 4\ AC < 0$. Substituting gives $4\cos^2\beta - 4$ for $B^2 - 4AC$. For $0° < \beta < 180°$, $B^2 - 4AC$ is negative, indicating an elipse. Likewise for $180° < \beta < 360°$, $B^2 - 4AC$ is also negative, indicating again an eliptical function.

30. It can be seen then, that the relationships between two sinusoidal functions (e. g. log MPN and tidal height) with time as the parameter yields either a straight line or an ellipse, depending on the phase angle difference between the two functions. In essence, the results of this analysis in the application to the Narragansett study have been visualized as a fixed-parameter linear system, which may be defined by considering that a unit impulse in the input function (e. g. tidal height) produces a unit impulse in the output function (e. g. log MPN) and the nature of the function relating these two variables can be determined by the ratio of the amplitude. Finally, it is assumed that the results of the sinusoidal analysis, as discussed previously, represent an output function as a result of a given input function with all other possible input functions being "short circuited." In other words, the sinusoidal relationship for a given variable over a given time cycle is assumed to be that output function resulting from the input function implied by the use of the particular cycle.

APPENDIX B

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